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COMPARATIVE INVESTIGATION OF HIGH-LATITUDE IONOSPHERIC STRUCTURE AND EFFECTS NEAR SOLAR MAXIMUM

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Northwest Research Associates (NWRA) has recorded a database containing measurements of the intensities of two L-band signals transmitted by satellites of the Global Positioning System and the differential carrier phase and differential group delay between them. Data collection was carried out during the period December 1990 - December 1992, which immediately followed the recent solar maximum. Data collection equipment, operated and serviced by NWRA, was located at Hanscom AFB, MA; Lerwick, Shetland Island, UK; and Thule AB, Greenland. Software tools to test, quality check, reduce, analyze, and display the data were developed. The total electron content data from the sub-auroral station (Lerwick, Shetland Island, UK) have been well analyzed and are shown to provide extremely detailed morphology for all times, seasons, and levels of magnetic activity. A log detailing the availability of data according to date, site, receiver type, and data quality is included herein.

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I. INTRODUCTION AND OBJECTIVES

Northwest Research Associates (NWRA) has recorded a database containing measurements of the intensities of two L-band signals transmitted by satellites of the Global Positioning System (GPS) and the differential carrier phase (DCP) and differential group delay (DGD) between them. Data collection was carried out during the period December 1990 - December 1992, which immediately followed the recent solar maximum. This database contains information collected at Thule AB, Greenland; Lerwick Observatory, Shetland Island, UK; and Hanscom AFB, MA, and represents a range of latitude and longitude regions. Software has been developed that processes these data and produces measurements of trans-ionospheric absolute total electron content (TEC) and L-band scintillation. This database contains morphology of TEC in the polar cap and in the region of the BMEWS SITE-III radar at Fylingdales, UK, near solar maximum.

The purpose of this effort was to complete a database sufficient to characterize TEC variations and scintillation at high latitudes near solar maximum and to document the behavioral trends therein. One specific objective of the project was to complete a database that allows improved characterization of TEC variations and scintillation at high latitudes near solar maximum. These data are suitable for analyses aimed at both Air Force systems at transition and higher latitudes and understanding of ionospheric behaviors that affect those operations. The second objective was to advance the behavioral description and understanding of plasma-density structures within geomagnetic latitude regimes identified with the main ionospheric trough, the auroral oval, and the polar cap during years near the peak of the eleven-year cycle in solar activity. This will form a basis for operational and, potentially, design decisions regarding surveillance radars, with possible applications to transionospheric communications systems.

To accomplish these goals, NWRA has maintained and operated (or directed the operation of) receiving equipment at Thule AB, Greenland; Lerwick Observatory, Shetland Island, UK; and Hanscom AFB, MA. The received TEC and scintillation data have been stored on various magnetic media. Software was developed to reduce and analyze the data to advance the understanding of the nature and development of ionospheric structures within the regions monitored. Software was also developed to apply the database to characterizing the transionospheric radio channel.

II. DATA COLLECTION AND PROCESSING

During the 22-month study period, NWRA maintained and operated (or directed the operation of) data-collection equipment at Thule AB, Greenland; Lerwick Observatory, Shetland Island, UK; and Hanscom AFB, MA.

A. Description of Instrumentation

The government furnished equipment (GFE) operated and serviced by NWRA consists of Stanford Telecommunications, Inc. (STEL) STEL-5010 single-channel GPS receivers, a Texas instrument (TI) TI-4100 four-channel GPS receiver, Magnavox (MX) MX-1502 Transit receivers, and a National Institute of Standards and Technology Ionospheric Measurement System (NIMS) code-free, multi-channel GPS receiver manufactured by Atmospheric Instrumentation Research, Inc. (AIR).

The STEL-5010 located at Shetland Island experienced many failures during this study period. Many resources, both financial and manpower, were expended to maintain the site in an operating condition. This impacted the quantity and quality of data that were collected at the site, as well as the amount of data from all sites that were processed. Emphasis was placed on the reduction of TI-4100 four-channel GPS Shetland Island data, which are applicable to the BMEWS radar at Fylingdales, UK.

The STEL-5010 single channel GPS receiver tracks a single satellite for up to six hours. It measures the DGD between L1 (1575.4 Mhz) and L2 (1227.6 Mhz), the DCP between those two signals, and the received intensities of the L1 and L2 signals from the older, Block-1 GPS satellites only. It cannot receive the Block-2 satellites, whose L2 signals are encoded so the GPS selective availability function can be invoked. The data were recorded at twenty samples per second as binary files.

The TI-4100 four-channel receiver collected data simultaneously from four different GPS satellites, both Block 1 and Block 2. DGD and DCP were recorded at one sample per second. However, the DCP data experienced many drop outs, making these data unsuitable to phase averaging as a method of referencing. The DGD data were essentially continuous and, with proper antenna siting, contained minimal multipath. These DGD data were used to generate equivalent vertical TEC. Intensities of the L1 and L2 signal are not directly measured, therefore scintillation indices, S4, cannot be derived from the TI-4100 data.

The MX-1502 Transit receivers, located at Shetland Island, UK, and Hanscom AFB, MA, provide latitudinal relative TEC from north-south traveling satellites of the Navy Navigation Satellite System (NNSS). The transmitted signals from these satellites are at 150 Mhz and 400 Mhz. The sampling rate of this receiver is not fast enough to yield scintillation information. Each satellite pass lasts approximately fifteen minutes. In order to determine absolute TEC levels from the Transit measurements, which only provide relative TEC along the satellite track, complementary absolute TEC data are required to calibrate the relative TEC measurements. Absolute TEC information from the co-located GPS receivers provides such data.

The NIMS receiver is a code-free GPS receiver whose output is fifteen-minute averaged values of relative TEC. This receiver was acquired in April 1992 but required repair and was returned to AIR, Inc. Mr. Charley Andreasen (NWRA) identified several defects, all of which were confirmed and corrected by the manufacturer. The unit was installed at Hanscom AFB upon its return in May 1992. In a letter dated 27 July 1992, Mr. David B. Call, president of AIR, Inc., reported that this receiver fails to meet the specified accuracy levels. The problem manifests itself

in rapid fluctuations in measured TEC that are due to the antenna and choke-ring assembly, not the ionosphere. AIR intends to correct this problem with a redesigned antenna. However, the data from this unit are necessarily of doubtful quality due to this design problem.

B. Instrumentation and Operation at Each Site

THULE AB

One STEL-5010 single-channel GPS receiver was operated at the Thule AB site. The receiver reliably collected data throughout most of the study period. Based on sample data that have been processed, the quality appears to be good. Appendix 4, Near Solar Maximum Database, may be referenced to determine coverage for a specific date. Information pertaining to the maintenance, equipment calibration, problems, and repairs at this site are detailed in Appendix 1.

SHETLAND ISLAND

At the Shetland Island site, NWRA directed the operation of three receivers: an STEL-5010 single-channel GPS receiver, a TI-4100 four-channel GPS receiver, and an MX-1502 Transit receiver. In addition, a Transit receiver operated by the University College of Wales (UCW), Aberystwyth, UK, collected data at this site. The STEL-5010 experienced many failures during the study period, and reliable TEC and scintillation data are available only from the November 1991-June 1992 period. The TI-4100 operated reliably from December 1990 - February 1992, when it was sent, at Phillips Laboratory's request, to Applied Research Laboratories, University of Texas at Austin (ARL-UT), to be calibrated and reprogrammed. Absolute TEC data quality for this period is good. Data collected by the MX-1502 Transit receiver are available from most of the November 1991-June 1992 period, and are of good quality. UCW Transit data are available from most of the study period. Appendix 4 may be referenced to determine coverage for a specific date. Information pertaining to the maintenance, equipment calibration, problems, and repairs at this site are detailed in Appendix 1.

UCW references their Shetland Island Transit data to the GPS data, both single- and four-channel, collected at Shetland Island by NWRA. The programs that plot the GPS data generate tables of time, TEC, latitude, and longitude, at five-minute intervals, which are used by UCW as reference.

HANSCOM AFB

Three receivers were operated at the Hanscom AFB site: an STEL-5010 single-channel receiver, an MX 1502 Transit receiver, and an NIMS code-free, multi-channel GPS receiver. The STEL-5010 collected data during the period December 1990-October 1991. Samples of data that have been processed indicate a problem with the DGD channel dropping out intermittently, making determination of equivalent vertical TEC from phase-averaged DCP impossible during those dropouts. The Transit receiver was installed in July 1991 and collected data through some of the remaining study period. The NIMS receiver was in operation from May 1992-December 1992, but, as discussed previously, antenna and choke-ring assembly design flaws resulted in poor

data quality. Information pertaining to the maintenance, equipment calibration, problems, and repairs at this site are detailed in Appendix 1.

In the Hanscom longitude sector, absolute TEC data for referencing the Transit measurements are available from sources other than the co-located receivers. From January 1991 through June 1992, data from a geostationary satellite were collected using a polarimeter located at Hamilton, MA. These data can be requested through Mr. Jack Klobuchar at AFPL/GPIM, Hanscom AFB, MA. Ionosonde data collected at Millstone Hill, MA, are available in several different formats from World Data Center, Boulder, CO, and could also be used as reference. (Ionosonde data, collected during the contract period, with approximately 90 % yearly coverage, are also available from Qânâc, Greenland, and Narssarssuaq, Greenland.)

C. Absolute Total Electron Content Data

Originally, it was planned to generate mean absolute TEC as one of the summary parameters contained in the processed database. Upon further consideration, it was decided that that value is not directly useful, due to the GPS satellites' geographic and local time spread. It was decided instead to analyze the data by separating them by latitude regions and plotting them. In this way, the behavior associated with the different latitude regions (trough edge/auroral, or auroral/polar cap) can readily be seen. In addition, the latitude-separated data may be plotted according to Ionospheric Penetration Point (IPP) adjusted time. To determine the IPP-adjusted time, the latitude and longitude of the IPP are first calculated. A time offset is added to the Universal Time Coordinated (UTC) time to reflect the time shift associated with the location of the IPP. Using this option, the TEC curves from two different satellites whose paths traverse the same region of the ionosphere will tend to overlap. This results in much more readily analyzed 24-hour TEC profiles. Figure 1 shows four channels' (trackers) data from the TI-4100 plotted individually with latitude and longitude of the IPP. A measure of variability of TEC with look direction is evident. For comparison, Figure 2 shows the same data that have been separated by latitude region and plotted versus IPP-adjusted time. Another comparison of UTC-plotted data and IPP-adjusted time plotted data is given in Figure 3. STEL-5010 single-channel data from Days 16 through 23, 1992 are overplotted in both UTC- and IPP-adjusted time.

Measurements of DGD, from which absolute TEC can be determined, are very susceptible to contamination by multipath. The DCP yields a relative measure of TEC, containing a $2n\pi$ ambiguity. By referencing the DCP to the DGD through the phase averaging process, equivalent vertical TEC can be determined from DCP data.

TEC morphology for the TI-4100 was derived from DGD alone, due to the intensive labor input that would have been required to perform phase linking of the discontinuous DCP data to support the phase-averaging process. Multipath is present in this DGD data, but due to the antenna having been located in an open field, its magnitude is about $\pm$ 2 to 3 TEC units. The STEL-5010 data, on the other hand, had continuous DCP data on most of the passes, and this was used to eliminate multipath from the absolute TEC data.

The program that plots the data according to latitude could be further modified to generate a plot of the mean diurnal TEC curve over some desired interval, for example, one week.

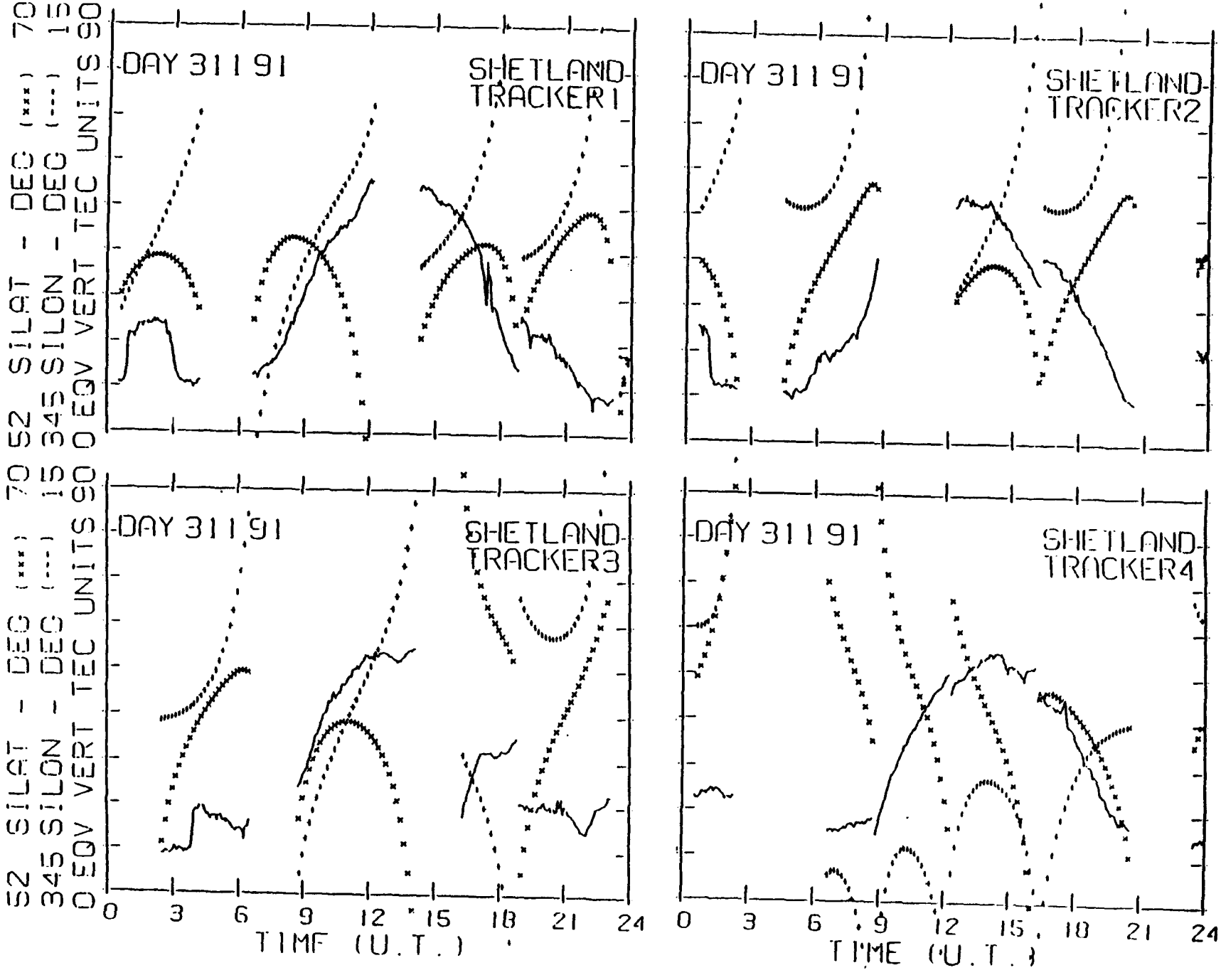


Figure 1. TI-4100 Four-channel data showing latitude and longitude of IPP.

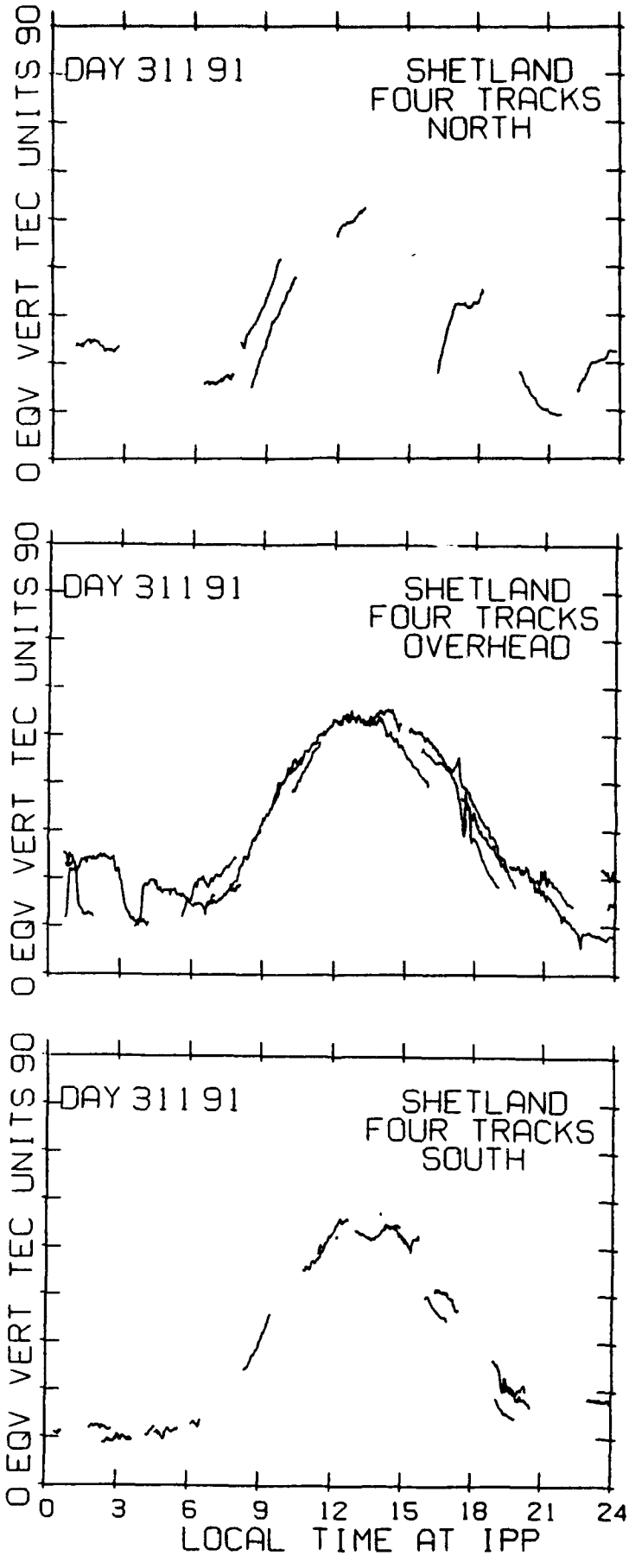
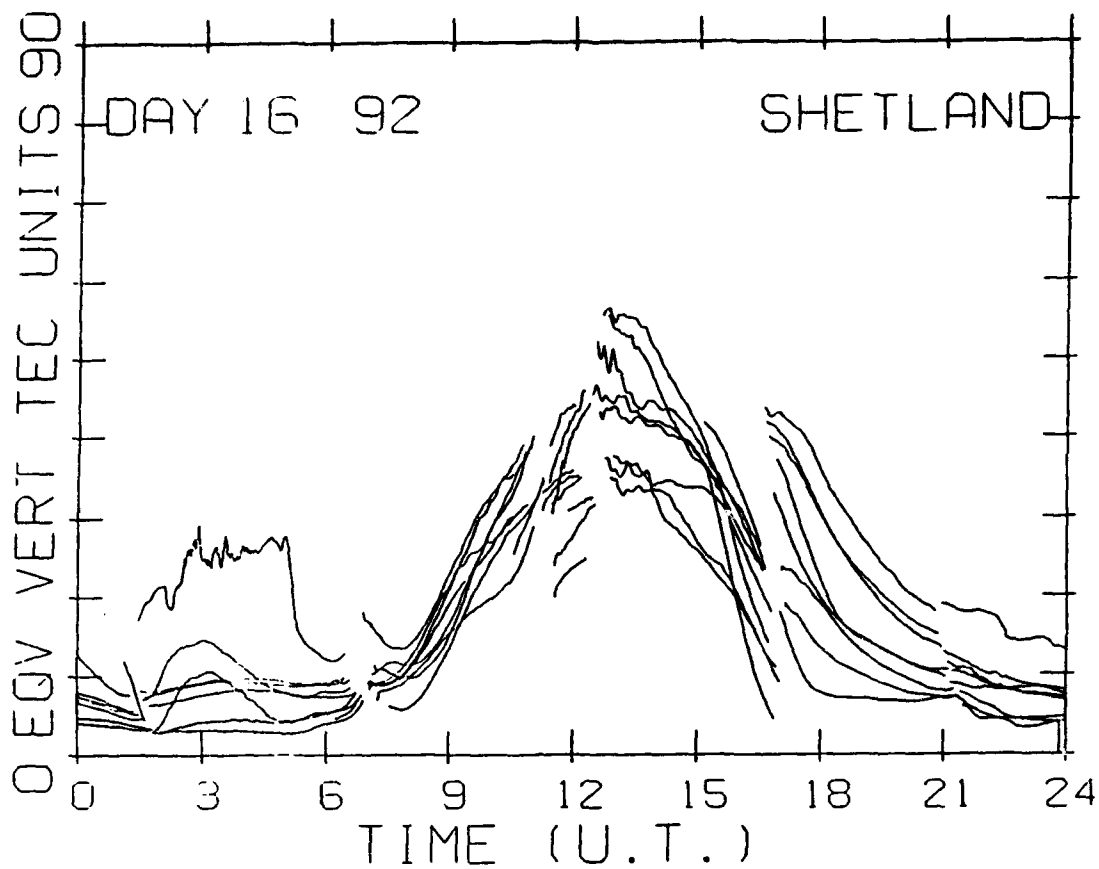


Figure 2. TI-4100 Data separated by latitude.



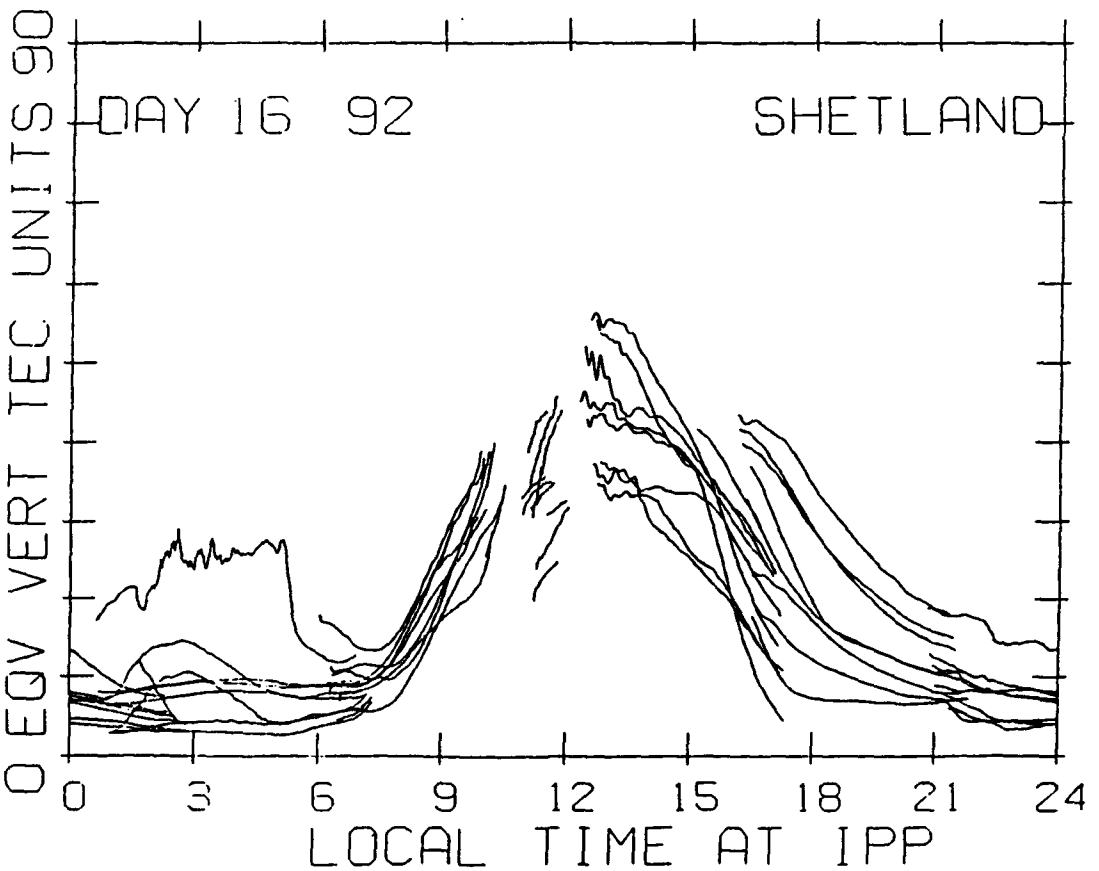


Figure 3. STEL-5010 Data plotted vs UTC and IPP adjusted time.

To do this, the TEC values at each time for each data day could be averaged together in an array during overplotting, and that array could then be plotted as a mean diurnal TEC curve after the requested several-day overplot was produced.

D. Approach for Statistical Assessment of TEC Variation and Scintillation

During periods of high planetary Kp index, the occurrence of scintillation and the magnitude of TEC variations are increased, making these periods especially valuable for study. First-order statistical measures, such as standard deviation of relative TEC variation and L-band intensity scintillation, are quantities of interest. Single-channel data from the STEL-5010 systems are best suited to an analysis of these quantities since it alone provides scintillation data and since the four-channel data, as noted before, suffers breaks in phase continuity which would be very labor intensive to correct. Equivalent vertical TEC that has been derived from phase-averaged and slant-factor corrected DCP could be detrended, and the standard deviation could then be calculated. It is necessary to use phase-averaged, slant-factor corrected DCP data since noise also scales up at low elevation.

E. Software Tools Developed for Data Analysis

Appendix 3 contains a description of the software that was developed to process these data into a form suitable for analyses by both Air Force systems at transition and higher latitudes, as well as improved understanding of ionospheric behaviors that affect those operations. These programs can be used with any GPS data, in the same manner as they are used with the NWRA database: to test, quality check, reduce, analyze, and display the data.

The software developed during this effort reduces the raw data to files from which 24-hour plots, several-day overplots, pass-file plots, latitude-separated plots, and IPP-adjusted time plots of equivalent vertical TEC can be produced. S4 at L1 and L2 can be plotted as 24-hour plots or individual pass-file plots. A summary of the STEL-5010 data in tabular format can also be generated. This summary, shown in Figure 4, contains universal time of observation in seconds, amplitude scintillation index (S4) at L1 and L2, slant path TEC, RMS dispersive phase from DCP measurements, azimuth and elevation angle of the satellite from the observing station, and geomagnetic latitude, longitude, time, and penetration angle at the 350-km IPP. These programs can be used with any GPS data, such as those collected by the planned Trans-Ionospheric Sensing System (TISS), in the same manner as they are used with the NWRA database: to test, quality check, reduce, analyze, and display the data.

A complete description of the available software to process the near solar maximum database resulting from this effort is given in Appendix 3. These programs can be used with any GPS data, such as that collected by the planned TISS.

F. Database

The near-solar-maximum database in Appendix 4 details the availability of data according to date, site, and receiver type, and indicates the level to which the data have been processed and the quality of that processed data. Each of the 25 pages shows one month broken down into

lerwick UT(secs)	S4-L1	S4-L2	slantTEC	rmsdcp	azimuth	elevation	p.angle	*** gmaglat	350 km penetration point gmaglon	gmagtim
8355.	.0597	.1119	41.9740	.3491	282.810	58.108	30.006	59.580	79.123	2.856
8375.	.0653	.1166	42.1650	.3734	282.918	58.259	29.866	59.580	79.142	2.862
8395.	.0711	.1304	42.3460	.1919	283.026	58.410	29.726	59.579	79.161	2.868
8415.	.0687	.1309	42.3870	.2351	283.134	58.561	29.586	59.578	79.180	2.875
8435.	.0653	.1373	42.7530	.6649	283.243	58.713	29.444	59.577	79.199	2.881
8456.	.0653	.1385	43.2500	.6688	283.357	58.872	29.297	59.576	79.219	2.887
8476.	.0770	.1684	44.3860	1.0770	283.466	59.023	29.156	59.575	79.238	2.894
8496.	.0830	.1700	44.9300	.9659	283.575	59.174	29.016	59.574	79.256	2.900
8516.	.0888	.1786	45.7050	.5625	283.685	59.326	28.875	59.572	79.275	2.906
8536.	.0830	.1664	46.1160	.8100	283.794	59.478	28.733	59.571	79.294	2.912
8556.	.0803	.1787	46.8380	.6607	283.904	59.629	28.593	59.570	79.312	2.919
8576.	.0710	.1715	47.0410	.3685	284.014	59.781	28.452	59.569	79.331	2.925
8596.	.0714	.1692	46.8540	.4671	284.124	59.933	28.310	59.568	79.349	2.931
8616.	.0781	.1539	46.6220	.1947	284.234	60.085	28.169	59.567	79.368	2.937
8636.	.0816	.1499	46.4810	.2390	284.345	60.237	28.027	59.565	79.386	2.943
8657.	.0757	.1321	46.3770	.2871	284.461	60.396	27.879	59.564	79.405	2.950
8677.	.0687	.1257	46.1620	.1762	284.572	60.548	27.738	59.563	79.423	2.956
8697.	.0624	.1247	45.8530	.3915	284.683	60.701	27.595	59.561	79.441	2.962
8717.	.0715	.1401	45.3120	.6892	284.795	60.853	27.454	59.560	79.460	2.968
8737.	.0693	.1427	44.5250	.6936	284.906	61.005	27.312	59.558	79.477	2.974
8757.	.0699	.1429	44.0190	.4249	285.018	61.157	27.170	59.557	79.495	2.980
8777.	.0707	.1459	43.9980	.4080	285.130	61.310	27.028	59.555	79.513	2.987
8797.	.0824	.1648	44.5080	.6315	285.242	61.462	26.886	59.554	79.531	2.993
8817.	.0888	.1740	44.8480	.4214	285.355	61.615	26.743	59.552	79.549	2.999
8837.	.0996	.1883	44.4500	.9463	285.468	61.768	26.601	59.551	79.567	3.005
8857.	.0924	.1842	43.5380	1.0437	285.581	61.920	26.459	59.549	79.585	3.011
8878.	.0962	.1888	42.5900	.6487	285.700	62.081	26.309	59.548	79.603	3.017
8898.	.0835	.1586	41.7320	.8536	285.813	62.234	26.166	59.546	79.621	3.024
8918.	.0786	.1504	40.6200	1.2054	285.927	62.387	26.023	59.544	79.638	3.030
8938.	.0742	.1456	39.1500	1.3381	286.041	62.540	25.880	59.543	79.656	3.036
8958.	.0690	.1538	38.0840	.8718	286.155	62.693	25.737	59.541	79.673	3.042
8978.	.0690	.1510	37.6000	.3735	286.270	62.846	25.595	59.539	79.691	3.048
8998.	.0642	.1501	38.1450	.8431	286.385	62.999	25.452	59.537	79.708	3.054
9018.	.0755	.1545	38.8430	.8743	286.500	63.153	25.308	59.535	79.725	3.060
9038.	.0766	.1583	39.6650	.4578	286.616	63.306	25.165	59.534	79.742	3.066
9058.	.0767	.1669	40.1920	.5545	286.731	63.459	25.022	59.532	79.760	3.072
9079.	.0735	.1770	40.7300	.5413	286.853	63.621	24.871	59.530	79.778	3.079
9099.	.0773	.1824	41.4650	.7437	286.970	63.774	24.727	59.528	79.795	3.085
9119.	.0842	.1941	41.8570	.5636	287.086	63.928	24.583	59.526	79.812	3.091

Figure 4. Sample of summary parameters - output of GPSPCNW3.FOR.

days. Specified by site, the listing includes a column for each receiver type. An X indicates that raw data from that site, on that day, collected by that receiver, is available. An O appears if no data exist. In a separate column, Y for yes and N for no indicates if the data have been processed. The last column shows the quality of the data that have been processed: 0 if data not processed; 1 for good; 2 for questionable but possibly recoverable; and 3 for bad.

III. RESULTS

A. TEC Results: Shetland Island

The data collected at Shetland Island by the TI-4100 four channel GPS receiver yielded a great deal of data for studying TEC only. The TEC morphology of Shetland Island from March 1991 to February 1992 was determined by overplotting approximately one-week sets of equivalent vertical TEC derived from DGD. These are presented in Figures 5 - 16. As noted before, use of DGD alone was necessary due to the intensive labor effort that would have been required to perform phase linking on the DCP data in order to support the phase-averaging process. However, since the antenna was located in an open field, these curves contain multipath noise of about ± 2 to 3 TEC units. For cases of special interest (a few days), it is possible and reasonable to use the PLTREC7C.FOR program, link the DCP, and perform phase averaging. This would effectively eliminate multipath noise and the data would look like the TEC from STEL-5010 single channel GPS data.

A review of the year of weekly Shetland Island TI-4100 four-channel overplots in Figures 5 -16 shows that the TEC profiles exhibit variations dependent on time of day, season of the year, latitude, and Kp. The 24-hour plots of TEC show the typical cosine-like diurnal behavior of the mid-latitude ionosphere starting around 0900 hours and lasting until 1800 with the peak occurring at approximately 1200.

The data plotted begin in March 1991, where TEC levels were usually quite high during the day and there was significant variability, which is consistent with the large magnetic storm that occurred that month. April transitions from the high daytime TEC levels of March to the nearly "flat" diurnal behavior that tends to be seen during the summer months in the mid-latitude ionosphere. This flat behavior was seen to persist until September, which transitions to a clear post-midday peak and higher levels, though lower than was seen in March. The month of October tends to exhibit high TEC activity levels, with the last week of the month showing high variability due to a magnetic storm. November shows much disturbance, having high, medium, and low diurnal peaks. Kp levels were high during much of this month, with a large storm on Day 312. December shows very stable classic diurnal TEC variation throughout the month, with moderate maximum levels. This again is consistent with the lower Kp levels seen in December. January and February 1992 show more variability and higher TEC levels. Very high TEC levels were seen associated with the storm period of 02 - 03 and 08 February.

During periods of increased solar activity corresponding to high Kp, rapid variations in TEC levels and higher scintillation values are seen. Also, it is not uncommon to see the signature of the trough in the 24-hour TEC profiles. This is particularly evident in the 01 - 08 February

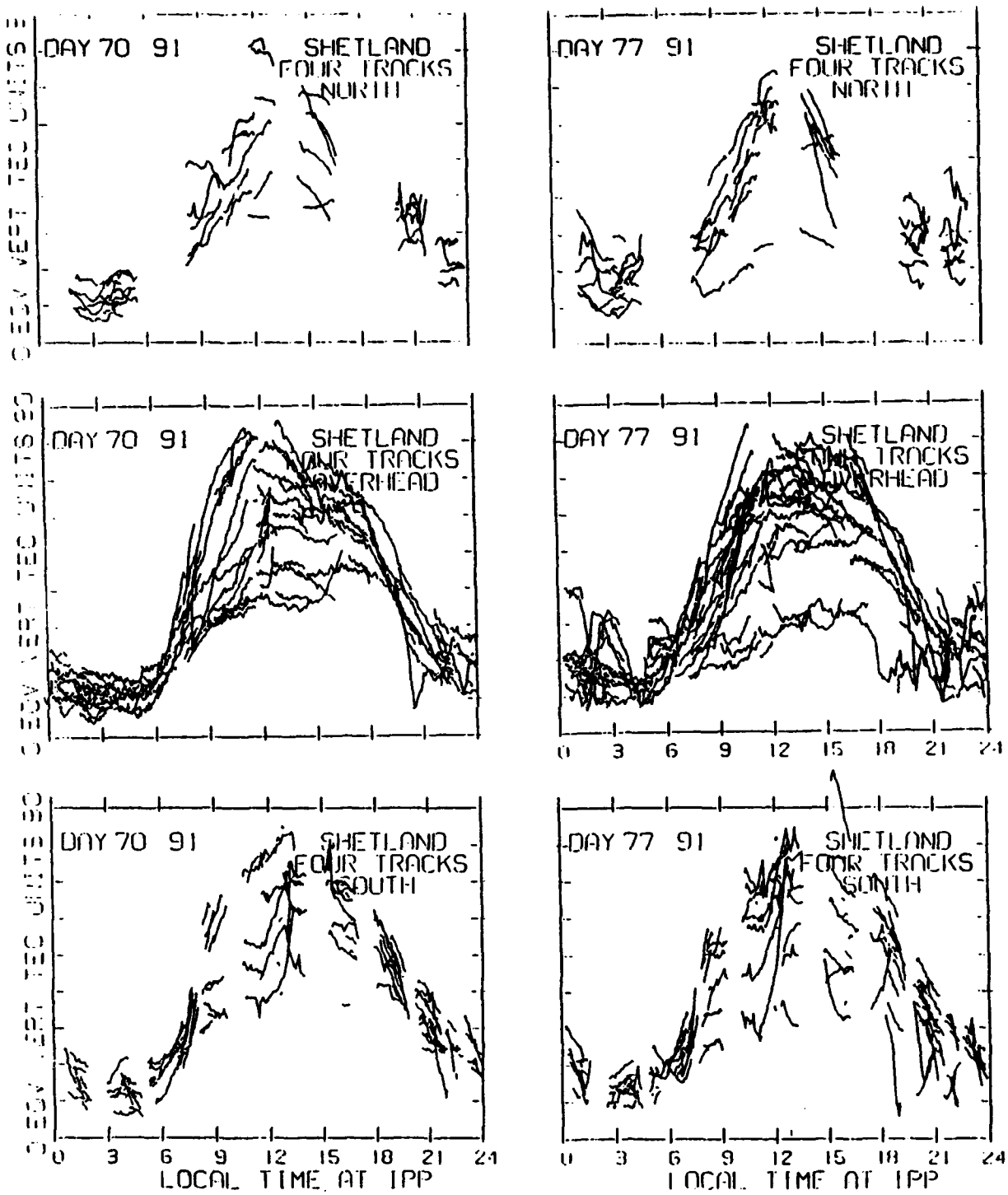


Figure 5. Latitudinally separated TI-4100 data - March 1991.

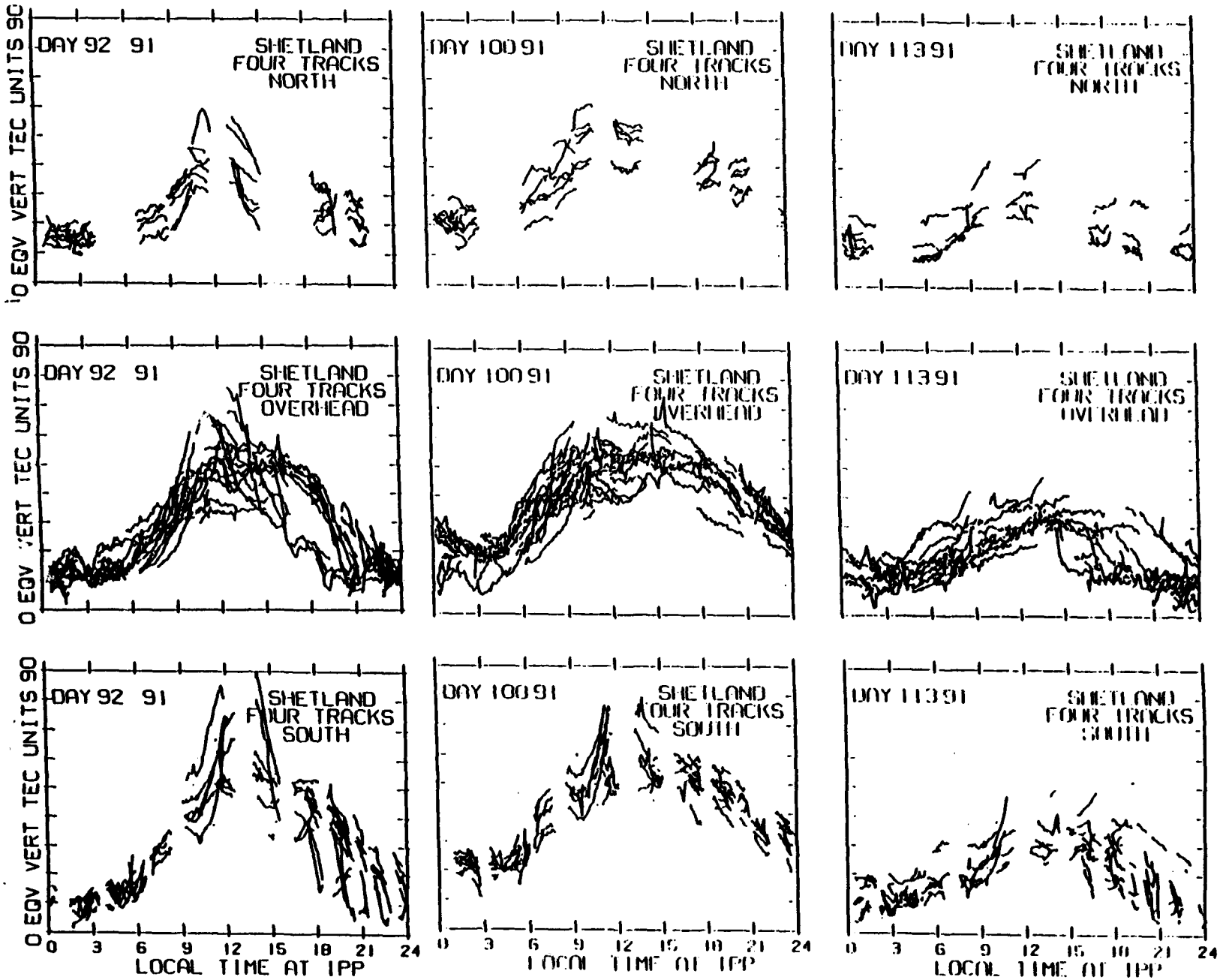


Figure 6. Latitudinally separated TI-4100 data - April 1991.

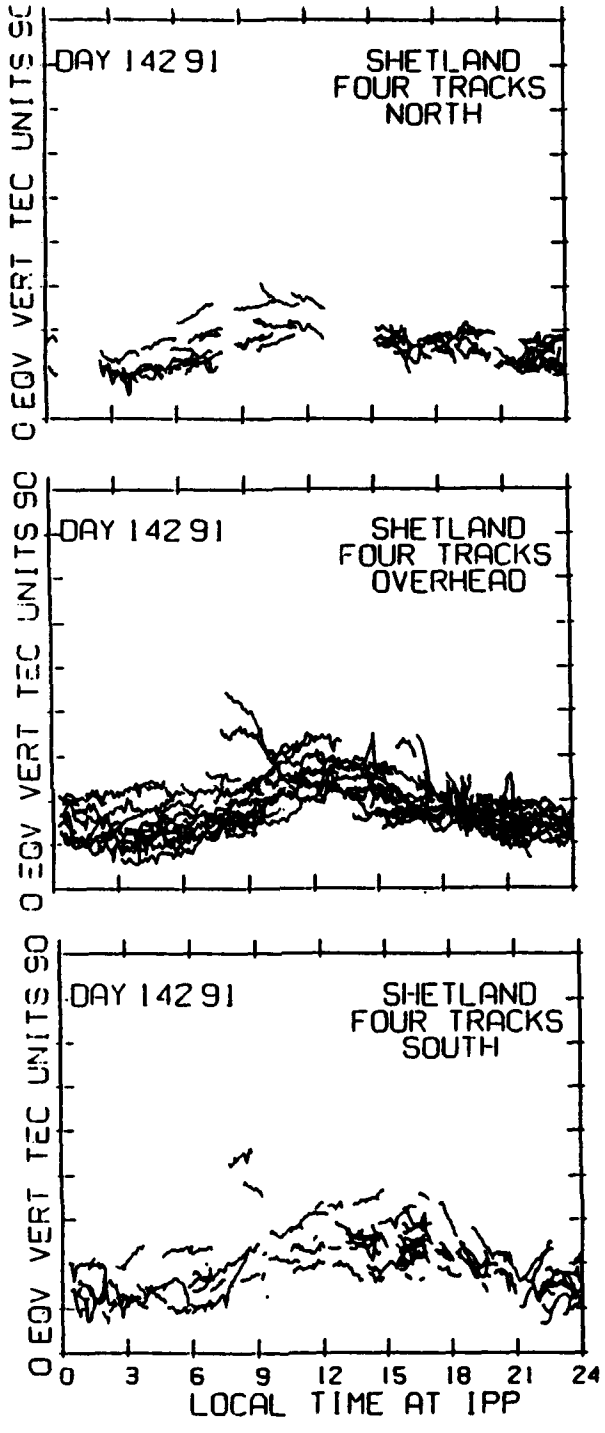


Figure 7. Latitudinally separated TI-4100 data - May 1991.

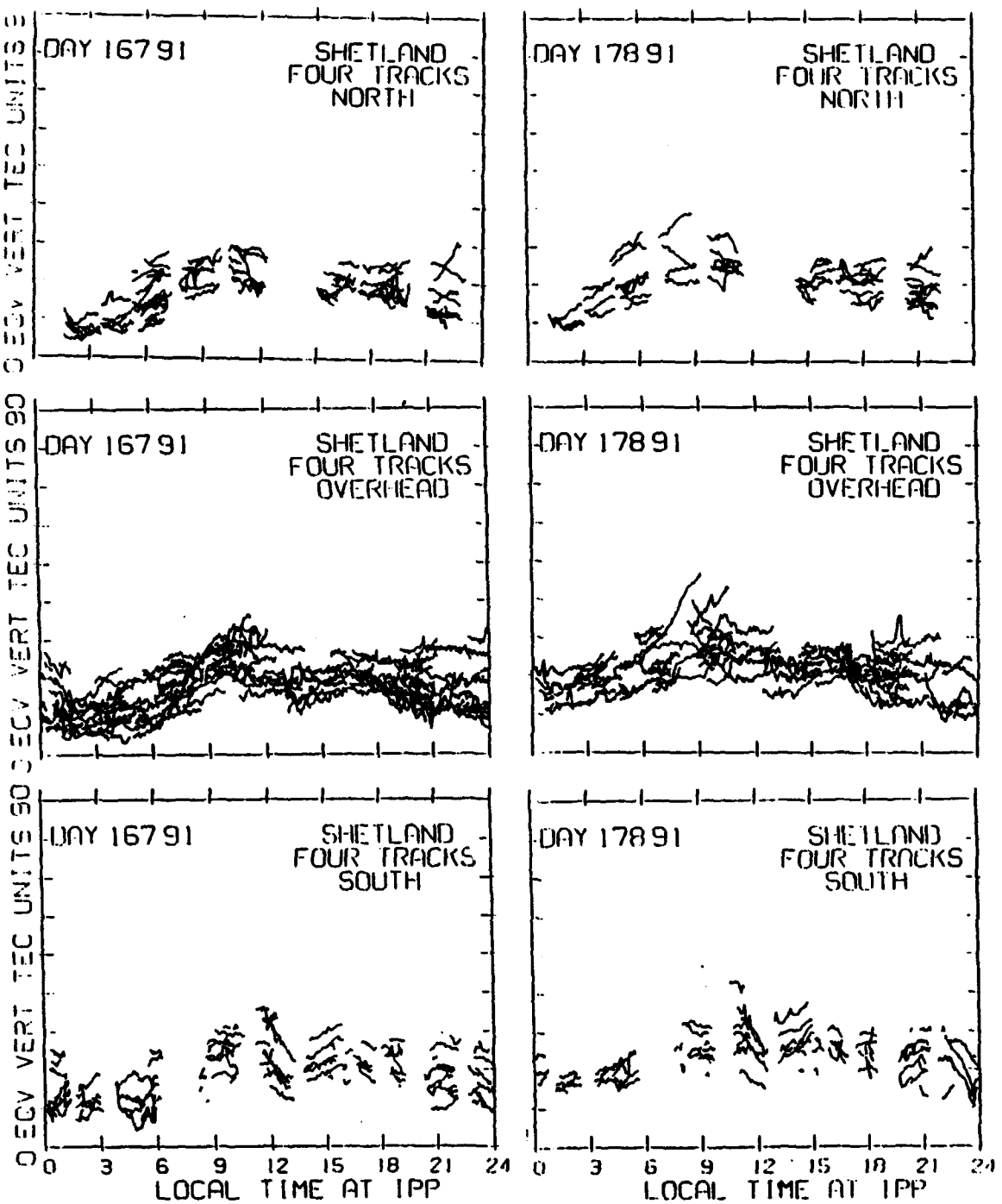


Figure 8. Latitudinally separated TI-4100 data - June 1991.

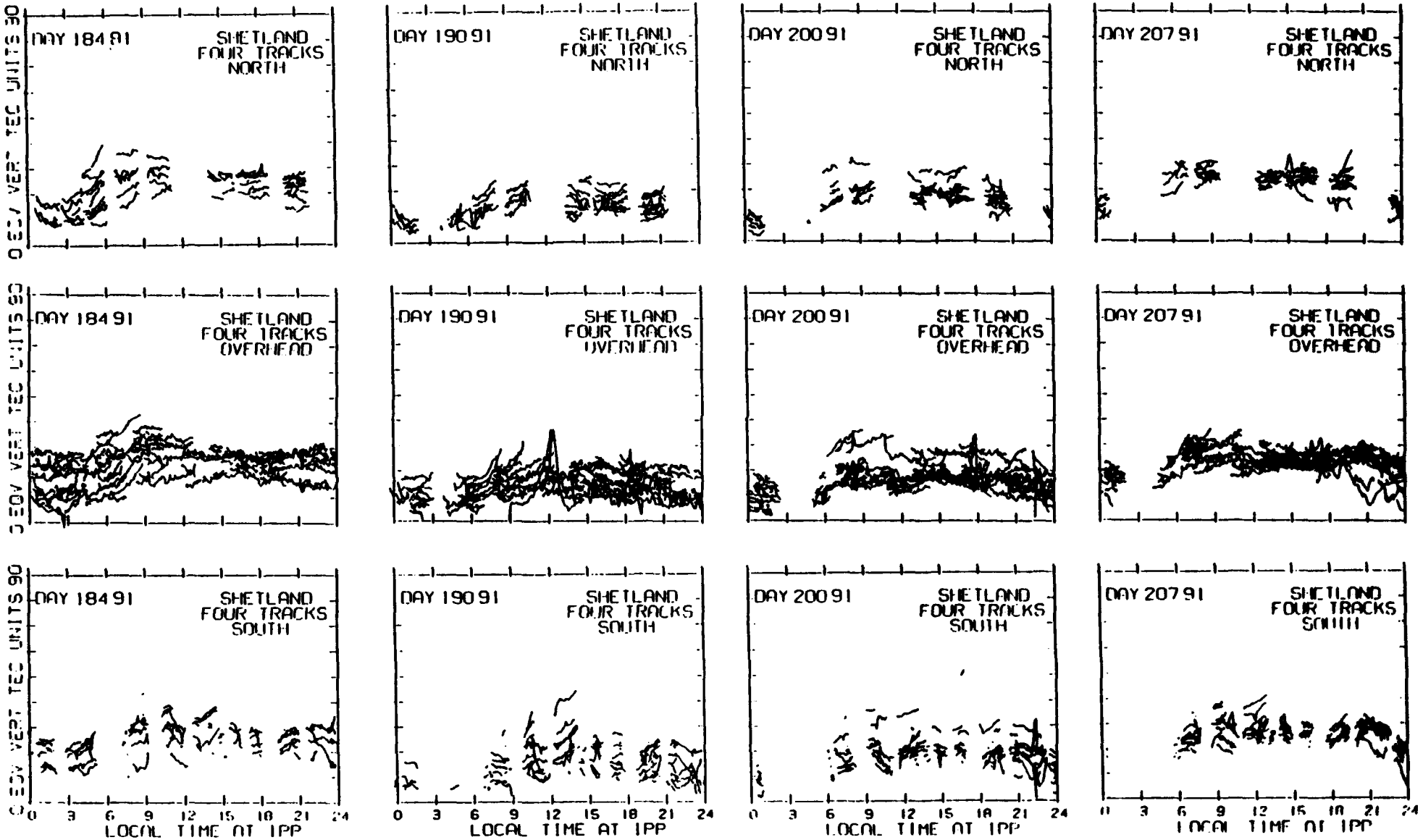


Figure 9. Latitudinally separated TI-4100 data - July 1991.

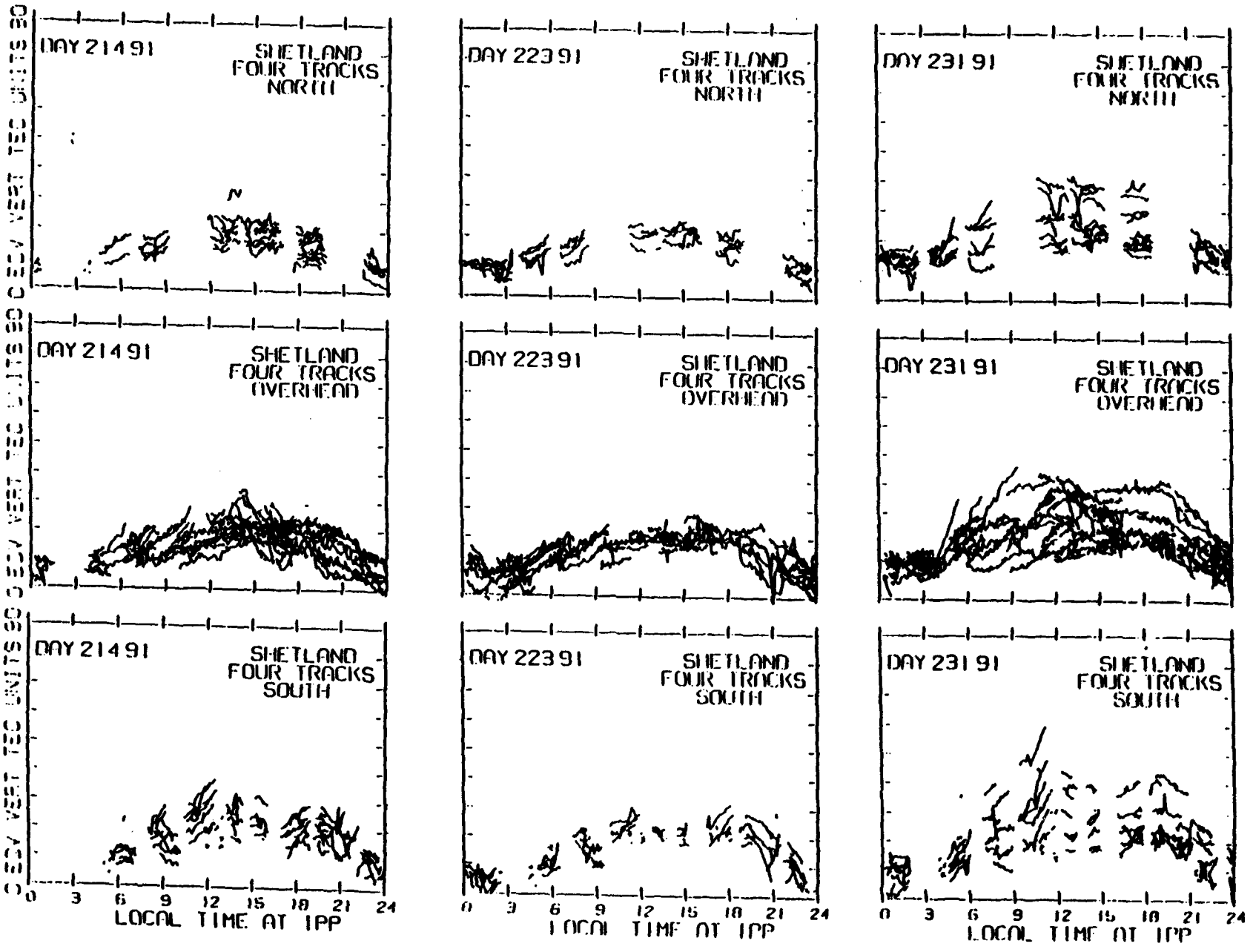


Figure 10. Latitudinally separated TI-4100 data - August 1991.

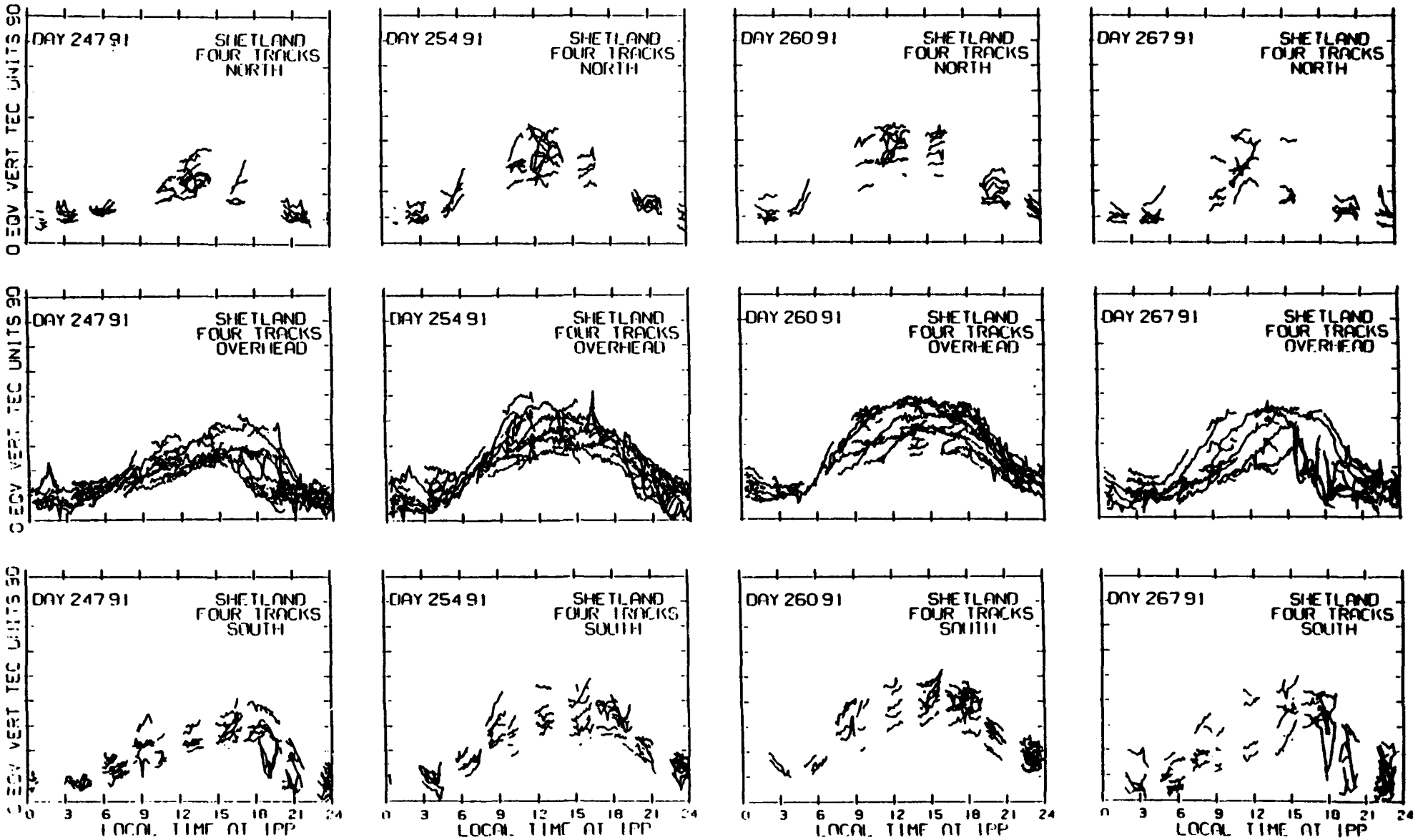


Figure 11. Latitudinally separated TI-4100 data - September 1991.

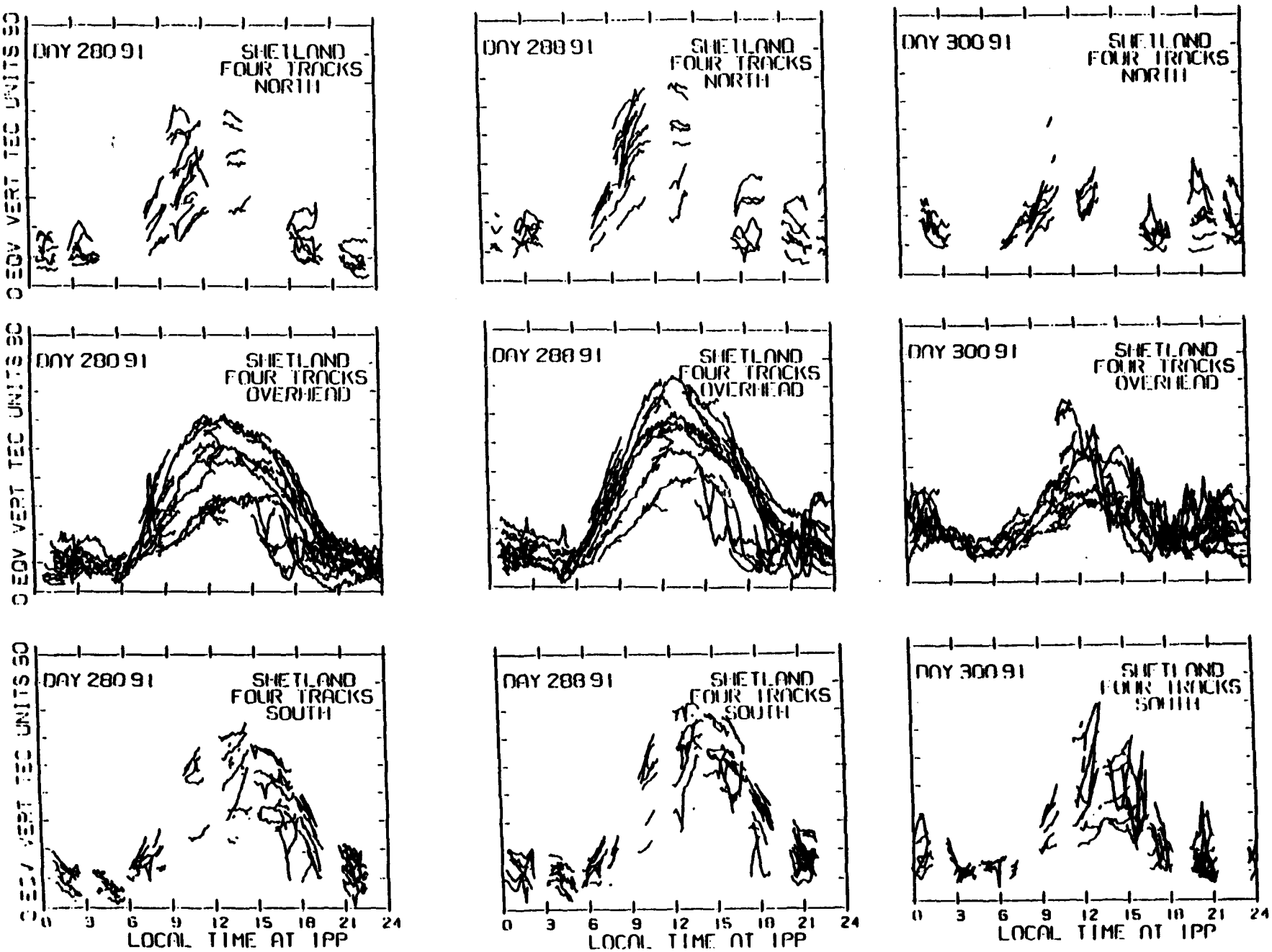


Figure 12. Latitudinally separated TI-4100 data - October 1991.

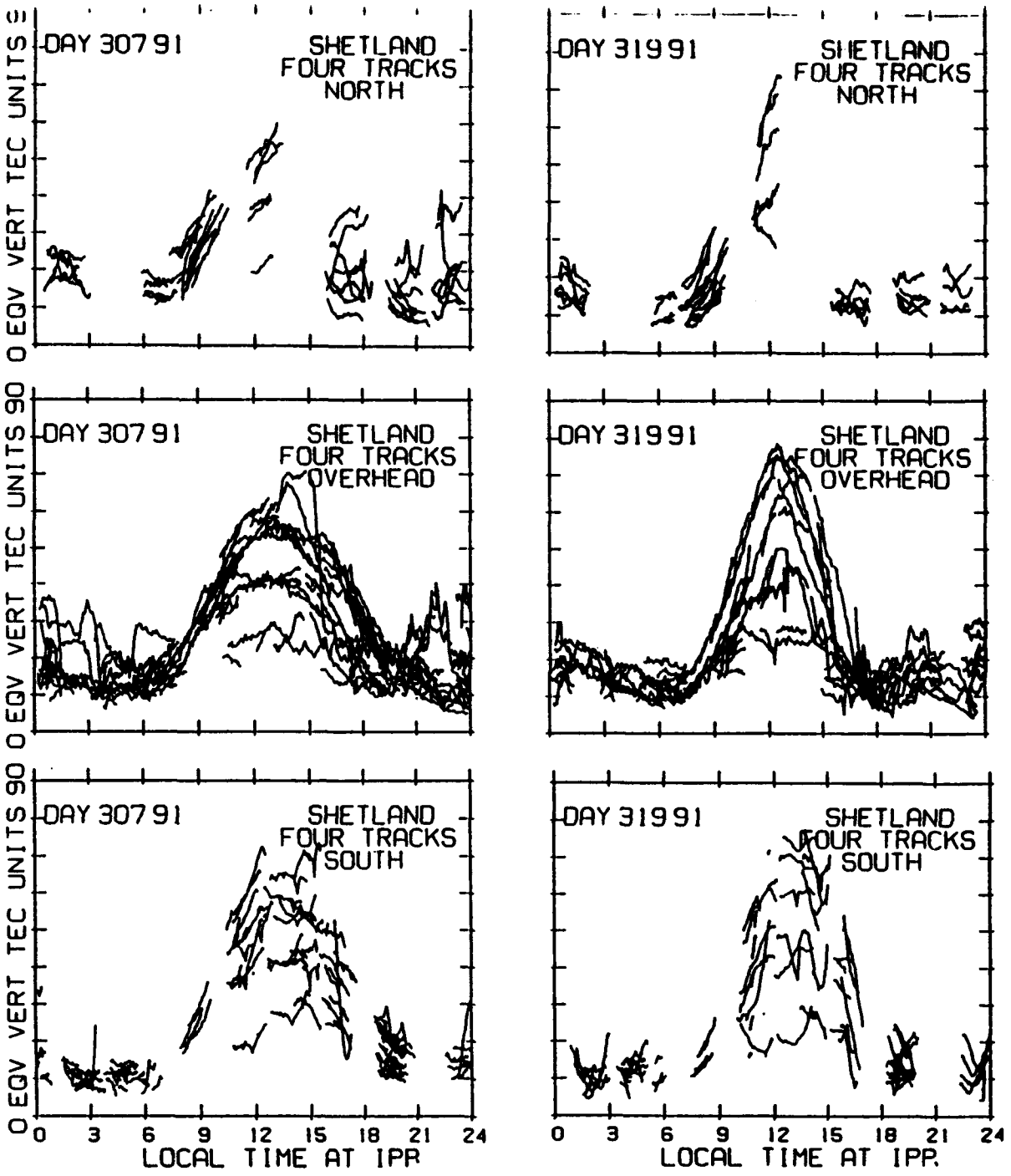


Figure 13. Latitudinally separated TI-4100 data - November 1991.

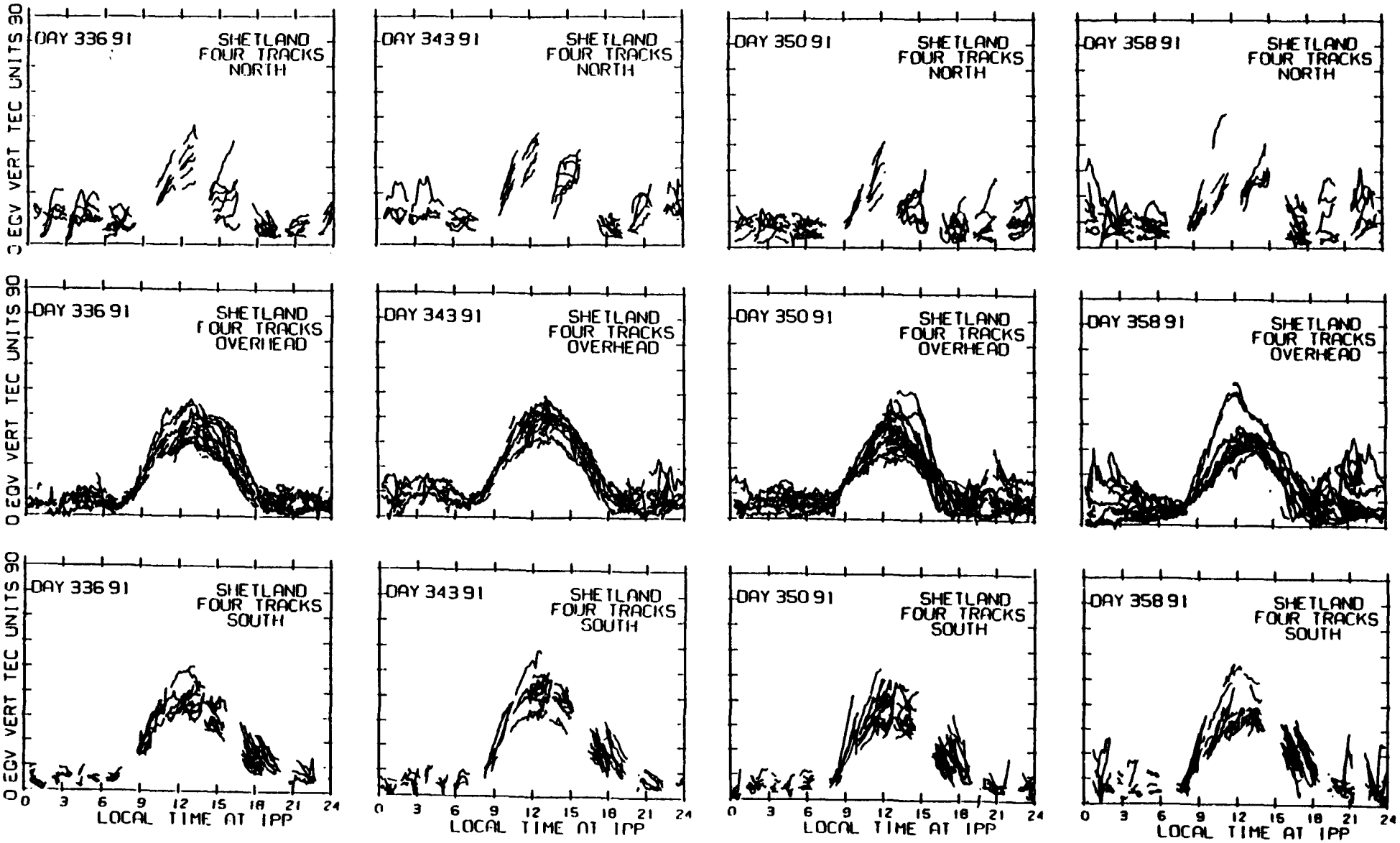


Figure 14. Latitudinally separated TI-4100 data - December 1991.

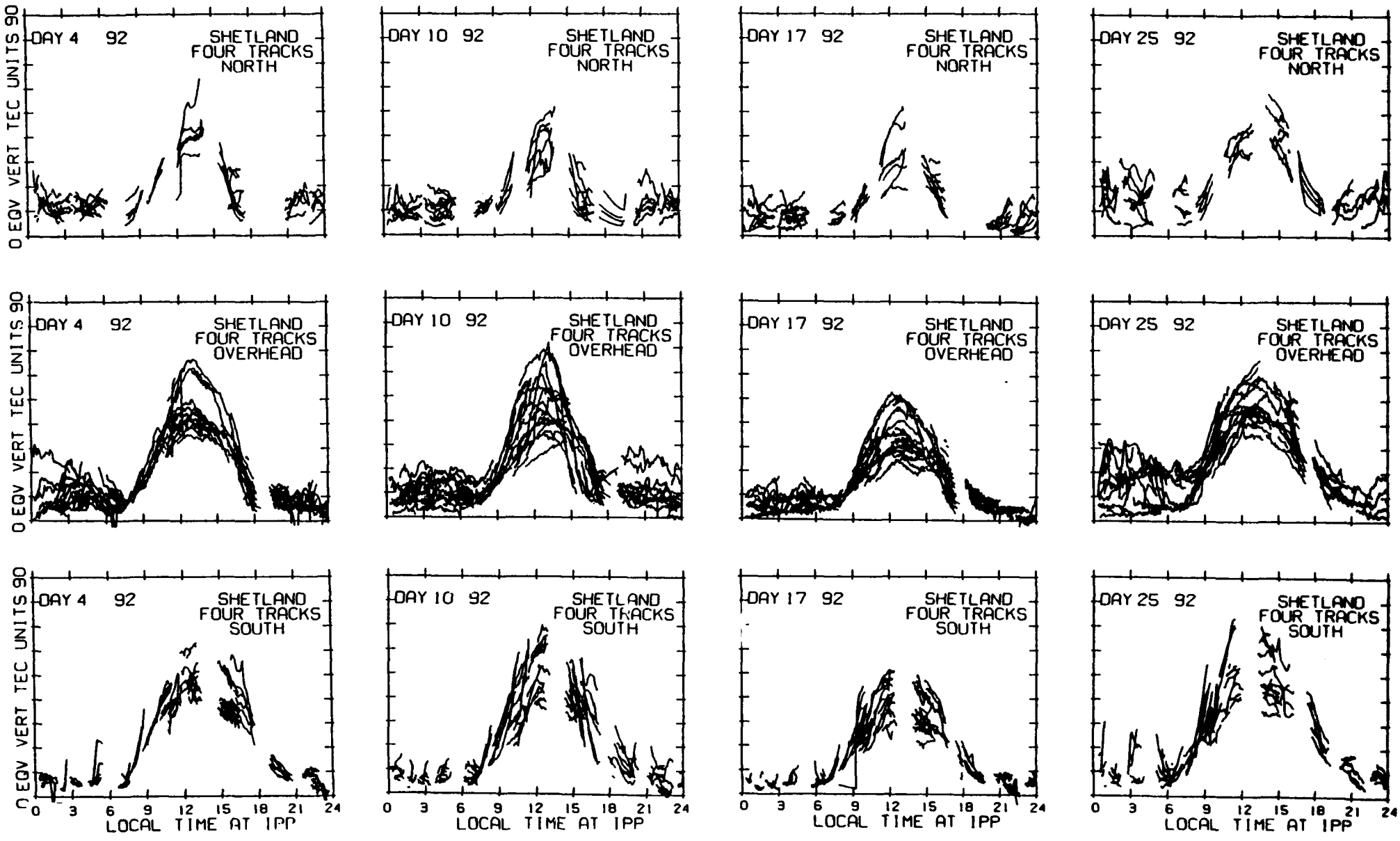


Figure 15. Latitudinally separated TI-4100 data - January 1992.

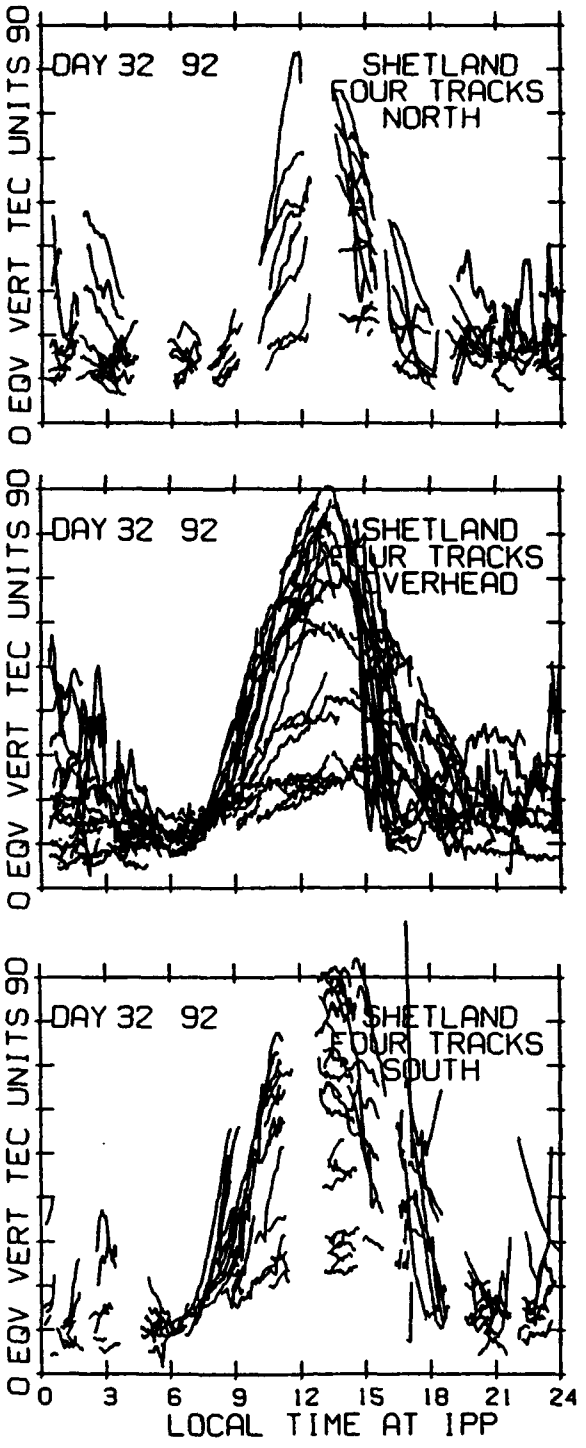


Figure 16. Latitudinally separated TI-4100 data - February 1992.

overplot shown in Figure 16 which includes the 02 - 03 and 08 February storms. The trough, a region of lower TEC density in the ionosphere, is typically located poleward from the midlatitudes. It is seen to move equatorward during periods of high Kp, and its signature is characterized by steepened gradients of TEC.

B. TEC Results: Other Sites

Similar overplots from single channel Shetland Island data can be, and in some cases have been, generated. These plots show the same behaviors as were seen in the TI-4100 data.

TEC morphology from Thule AB single-channel data, displaying behavior of the ionosphere in the polar cap region, can be produced from the database using the software tools developed under this effort.

Samples of the single-channel data from the Hanscom site indicate that there was a problem with the DGD data channel. The extent of this problem will not be known until more data are analyzed. However, should the data quality for some of the measurements be found to be good, similar overplots from Hanscom can be produced to provide insight into ionospheric behavior in that region.

C. TEC Results: Storm Time Examples

Data collected by the TI-4100 four channel GPS receiver from two magnetically active periods in November 1991 are shown in Figures 17 and 18. A chart of Kp level corresponding to these days is found in Figure 19. Days 301-307,1991 (28 October - 3 November, 1991) and days 311, 312, and 313, 1991 (7-9 November 1991) have been plotted according to north, overhead, and south latitude regions relative to the observing station's location. Plots of the magnetically quiet day 311 show the typical cosine-like midlatitude behavior. At 0100 to 0500 hours, the trough-wall signature is seen. There is a sudden commencement on day 312, and Kp levels rise to a high of nine over the next 24 hours. The trough-wall signature, characterized by steep gradients in TEC, is evident in these plots. Day 313 shows a relatively flat TEC profile in the latter half of the day as the magnetic storm ends and Kp levels return to zero. The technique of plotting latitudinally separated data allows viewing of the equatorward movement of the trough. In Figure 17, the trough-wall signature is seen at approximately 1500 hours in the overhead direction, and appears an hour later in the southerly data. Increased levels of TEC and the appearance of the trough wall are also seen in the overhead plots in Figure 18. These plots show distinct features in each latitude region. The overhead plot of days 306 and 307, as the storm is subsiding, shows the return to a more normal cosine-like shape and lower TEC values.

D. Scintillation Data

Single-channel data are available from all three sites concurrently, for a number of days in 1991 during periods of high planetary Kp. These times are March 24, 25, 1991; June 5, 6, 9, 10, 17, 1991; and October 28, 29, 31, 1991. A comparative analysis of the TEC profiles and scintillation between the two longitude sectors could be done using these data.

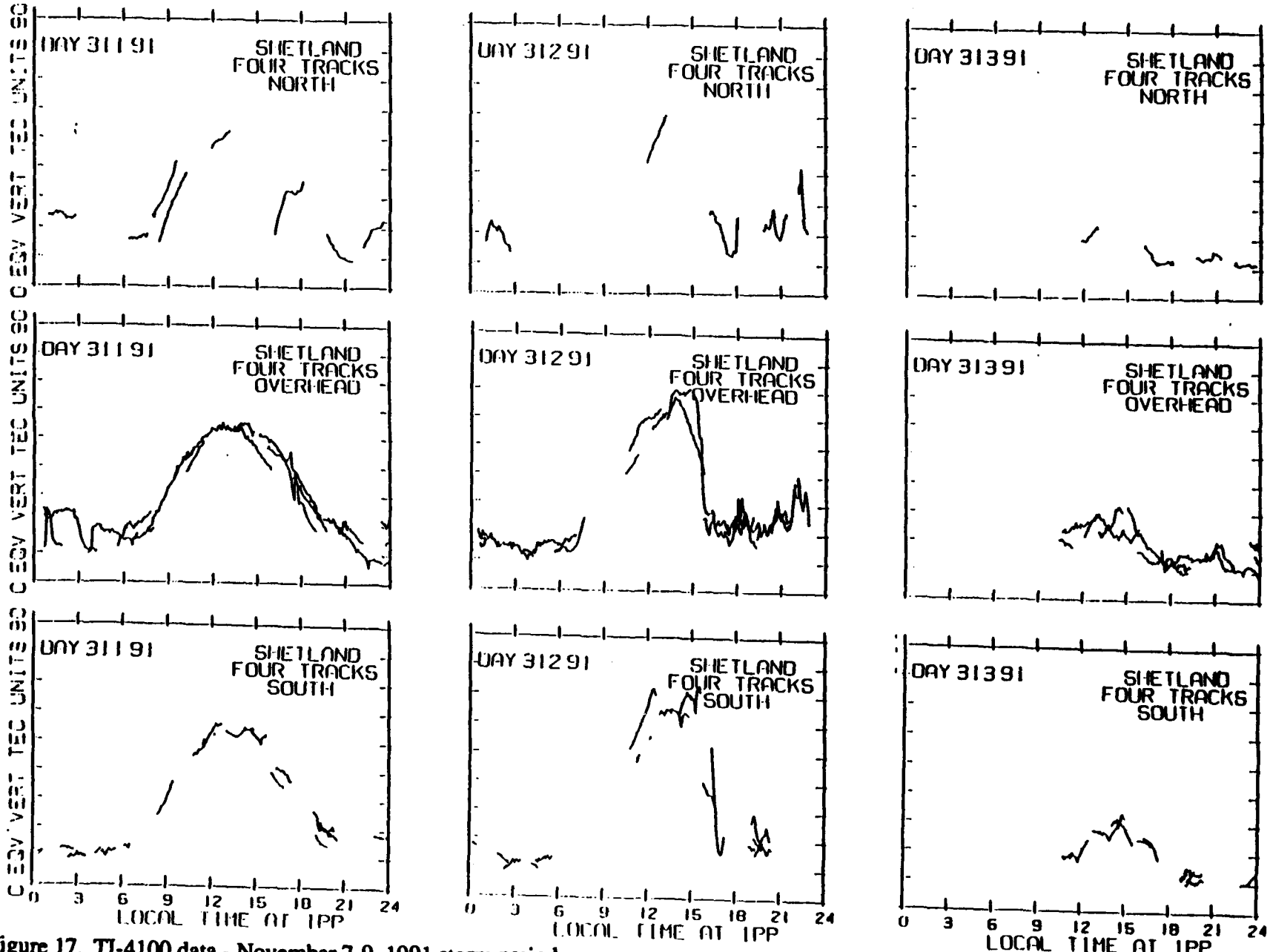


Figure 17. TI-4100 data - November 7-9, 1991 storm period.

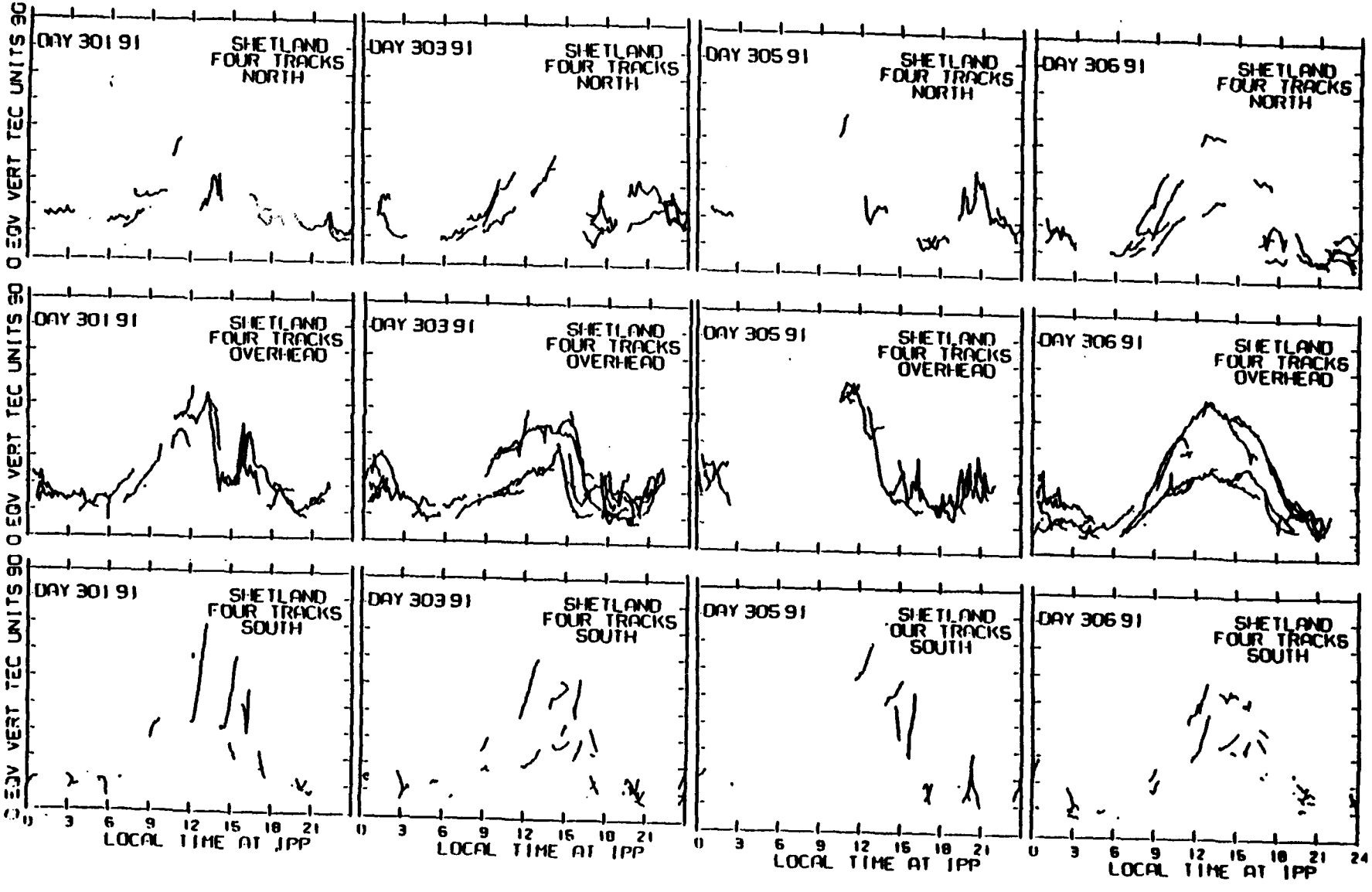


Figure 18. TI-4100 data - October 28 - November 4, 1991 storm period.

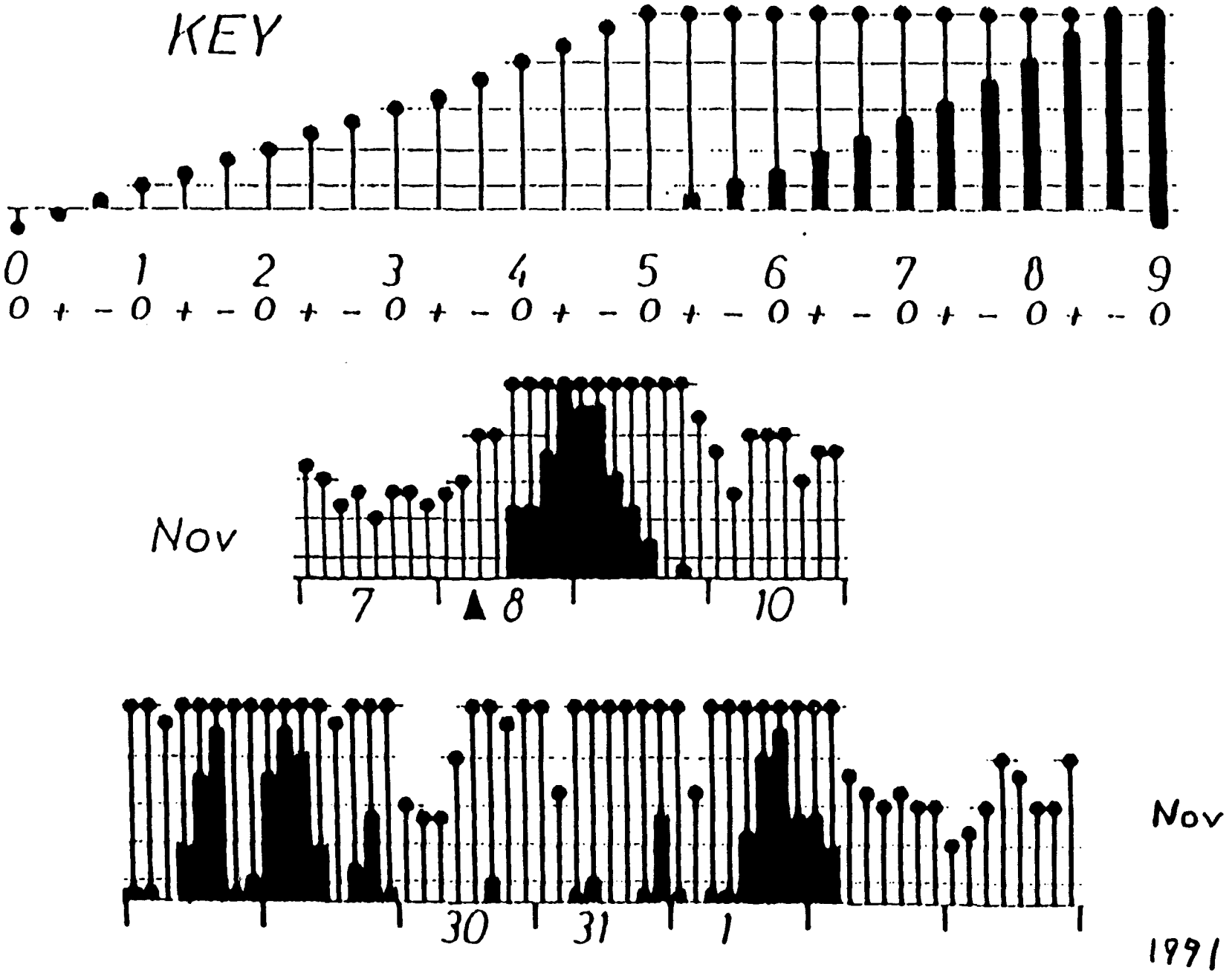


Figure 19. Detail of Kp levels during November 1991 storms.

An analysis was performed on measurements taken with the STEL-5010 receiver at Lerwick Observatory, Shetland Island, UK, on Day 327, 1991 to Day 60, 1992. Raw data were reduced using the GPSPCNW3.FOR program to produce propagation parameters associated with the transionospheric propagation path and consisting of amplitude scintillation index (S4) at L1 and L2, TEC over the slant path (in units of 10^{16} e/m^2), and the RMS variation in phase (also in equivalent TEC units). Geometry information stored with these parameters to facilitate data analysis consists of the elevation angle and azimuth of the satellite as seen from the ground station, the geomagnetic latitude and longitude coordinates of the 350-km altitude IPP, the incidence angle at the IPP, and geomagnetic time at the IPP. Geomagnetic coordinates used refer to the magnetic apex (Secan, 1987; VanZandt et al, 1972).

A limited study was performed that concentrated on the review and interpretation of available measurements during active periods. Initially the database was scanned and periods were identified when S4(L2) was greater than 0.20 for elevation angles of 30 deg or greater. A summary of episodes of enhanced scintillation and various measurement characteristics is listed in Table 1. As shown, amplitude scintillation index at L2 ranged from 0.261 to a maximum 0.558 and, in all but one instance, corresponded to high levels of planetary Kp index, which ranged from 2+ to 8. The geomagnetic latitude at the IPP intersection was mostly in the sub-auroral zone and varied from 55 to 62 deg. The measurements at Lerwick Observatory, Shetland Island, UK, normally show quiet scintillation conditions consistent with observations south of the auroral-zone scintillation boundary. During periods of activity, in most instances coincident with times of high planetary Kp index, the observations are consistent with the equatorward movement of the irregularity boundary.

1992 DAY	SAT	MAX S4(L2)	TIME (UT) (hours)	GEOMAGNETIC TIME (hours)	GEOMAGNETIC LAT. (deg)	MAX.% CHANGE TEC(V)	TIME (UT) (hours)	GEOMAGNETIC TIME (hours)	GEOMAGNETIC LAT. (deg)	Kp
16	3	0.405	23.20	23.82	57.89	39.7	23.08	23.68	57.67	5+
33	11	0.292	2.78	3.35	59.41	6.8	2.63	3.19	59.49	6
33	3	0.307	23.57	0.49	59.55	7.1	23.52	0.43	59.53	6
34	11	0.314	3.68	4.32	58.48	13.6	3.68	4.31	58.48	7
57	3	0.558	19.80	20.43	56.59	11.6	19.78	20.41	56.54	8
60	13	0.433	4.93	5.38	63.57	3.0	5.45	6.01	61.66	2+
60	3	0.261	20.10	20.78	57.67	6.4	20.11	20.78	57.68	5+

Table 1. Summary of Measurements During Active Periods at Shetland.

In each of the seven instances where enhanced scintillation was observed, the measurements are summarized using six graphic presentations, which are presented in Figures 20 - 26. The upper left-hand figure in each presentation displays the azimuth/elevation track of the satellite during the period of activity. The upper right-hand figure shows the geomagnetic latitude as a function of geomagnetic time. The middle plots show the equivalent vertical TEC (left side) and apparent fractional variation in slant TEC (right side) as a function of universal time. The bottom figures show plots of S4 index at L1 and L2 (left side) and geomagnetic latitude (right side) as a function of universal time.

With one exception, the scintillation analyzed occurred between four hours before and after midnight. The isolated activity event occured at five hours after midnight, and it differed also in that it was accompanied by only a 2+ level of Kp. In all the events, the S4 level was higher at the lower frequency (L2), as expected from propagation theory.

The reported fractional change in slant TEC is available from the preliminary processing at a 20 seconds per measurement interval and is the RMS measured TEC obtained at the 20 samples per second (SPS) rate over a one-minute measurement interval normalized by the average TEC. As defined here, the measured apparent fractional variation in TEC can be either a true variation in TEC (a refraction process) or indicative of a diffraction process or it can be a combination of both refraction and diffraction.

For example, in reviewing the graphical data covering the enhanced activity period on Day 16, the sharp change in vertical TEC near 2300 hours appears to be clearly related to large-scale refraction ionospheric effects. On the other hand, the rapid variation in the apparent fractional TEC shown in the next group of plots covering Day 33 shows rapid smaller fractional changes in TEC that appear to be more characteristic of a diffraction process.

E. Examples of TEC Data vs Model Prediction

Since the character of the ionosphere in the Shetland Island region is seen to vary, it is of interest to consider the accuracy of the model that is used to correct the range error of radar measurements. A statistical comparison between the USAF Environmental Tactical Application Center (ETAC) ionospheric model, based on the Bent ionospheric model (Llewellyn and Bent 1973) and actual measured values of TEC is accomplished using the Transit analysis software package developed by RDP, Inc., Waltham, MA. The statistical analysis is displayed as scatter plots of Bent-model predicted values of TEC versus measured values of TEC, and as histograms depicting the relative percent error between those two quantities. The data can be analyzed according to a specific elevation range, azimuth range, or time period.

The Transit analysis software was originally developed to work with Transit satellite data collected at Lerwick Observatory, Shetland Island, UK, by the UCW and referenced to the GPS data collected at Lerwick Observatory, Shetland Island, UK, by NWRA. It has been modified to accept also GPS data from Lerwick Observatory, Shetland Island, UK, directly, as in the examples of scatter plots and histograms shown in Figures 27 - 32. One week of Shetland GPS data from the TI-4100 four channel receiver from December 1991 are analyzed.

- LERWICK OBSERVATORY -
DAY 16, 1992
GPS MEASUREMENTS
SAT # 3

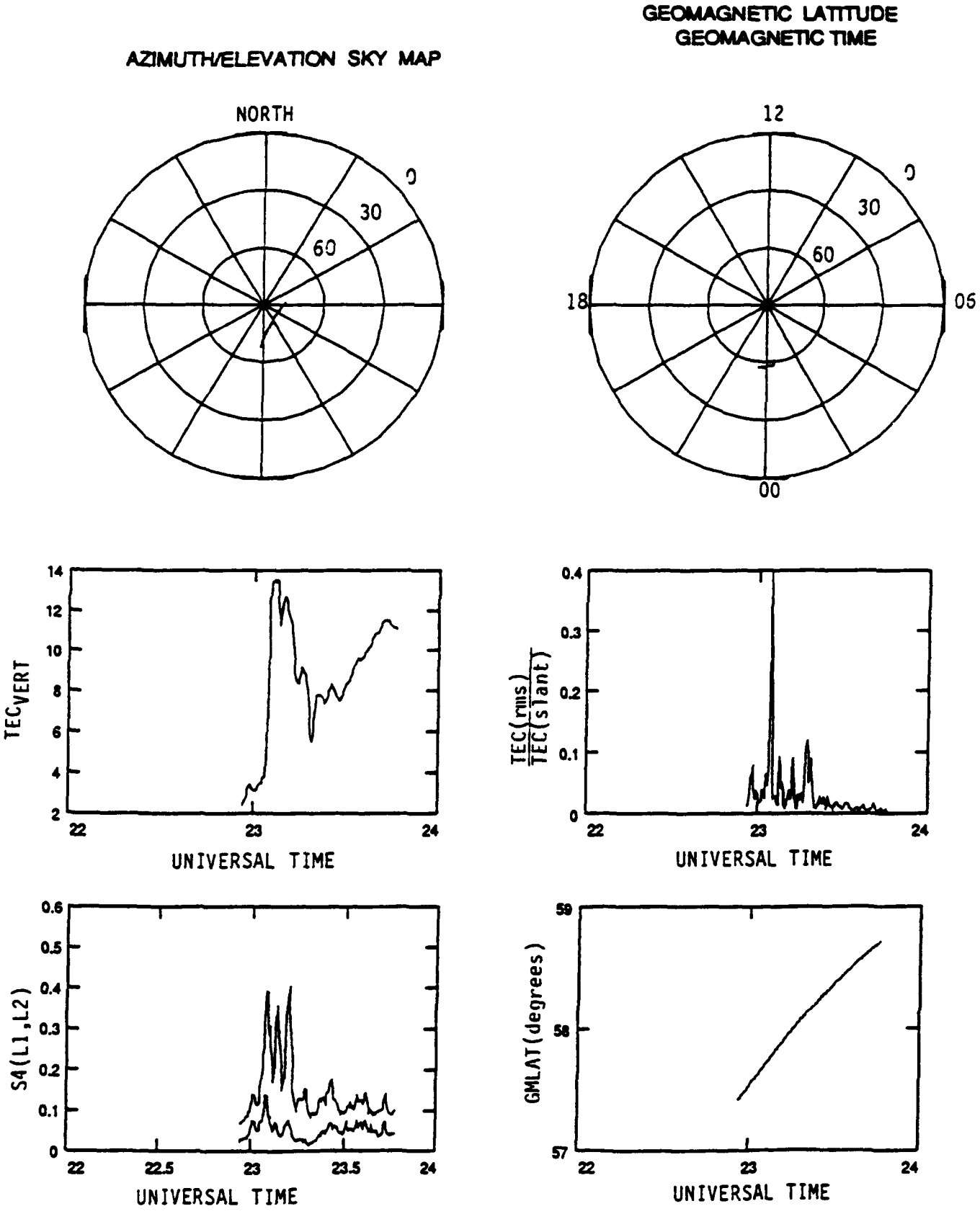


Figure 20. Graphical analysis of STEL-5010 Shetland data - Day 16.

- LERWICK OBSERVATORY -
DAY 33, 1992
GPS MEASUREMENTS
SAT # 11

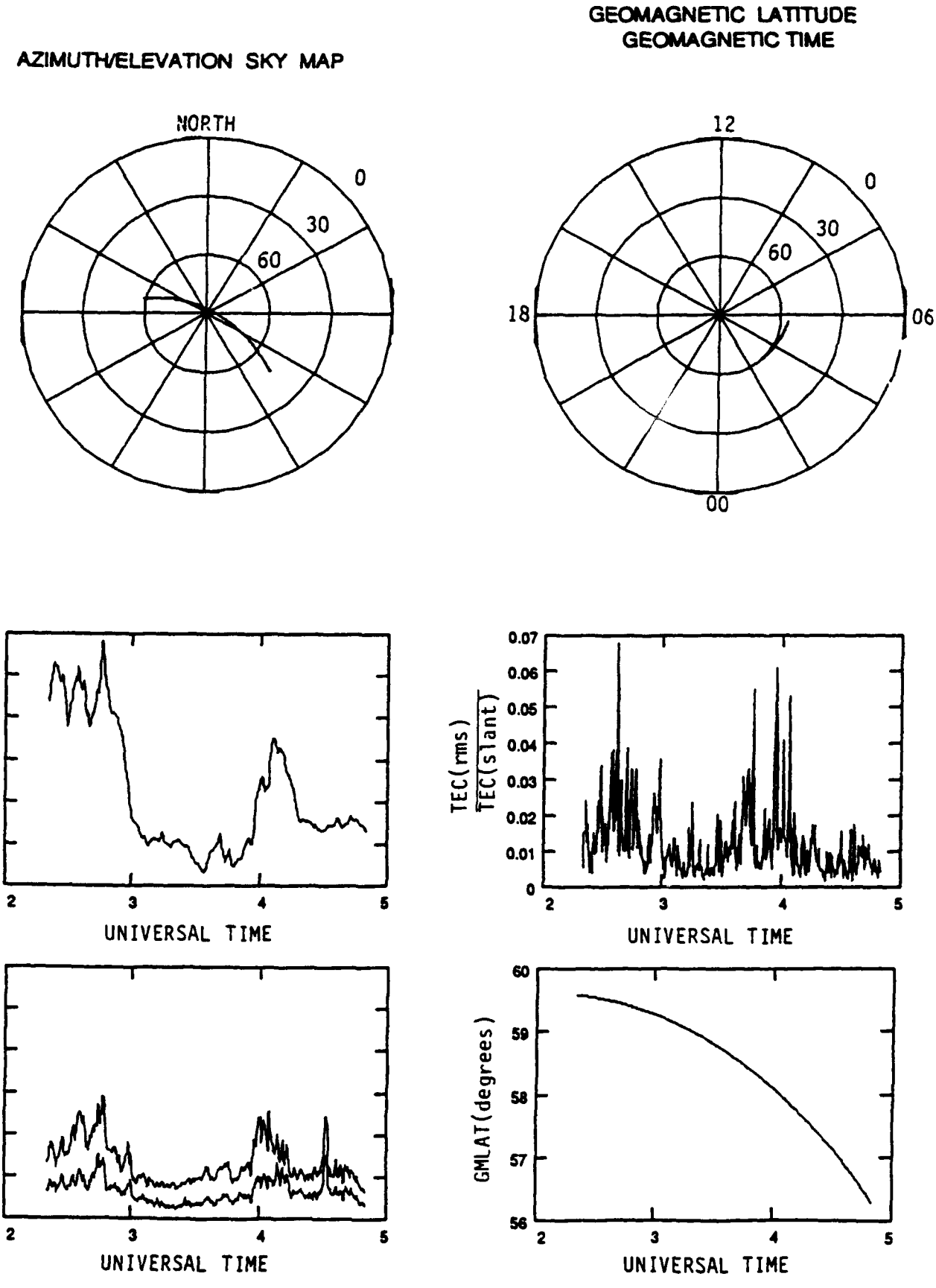


Figure 21. Graphical analysis of STEL-5010 Shetland data - Day 33.

- LERWICK OBSERVATORY -
DAY 33, 1992
GPS MEASUREMENTS
SAT # 3

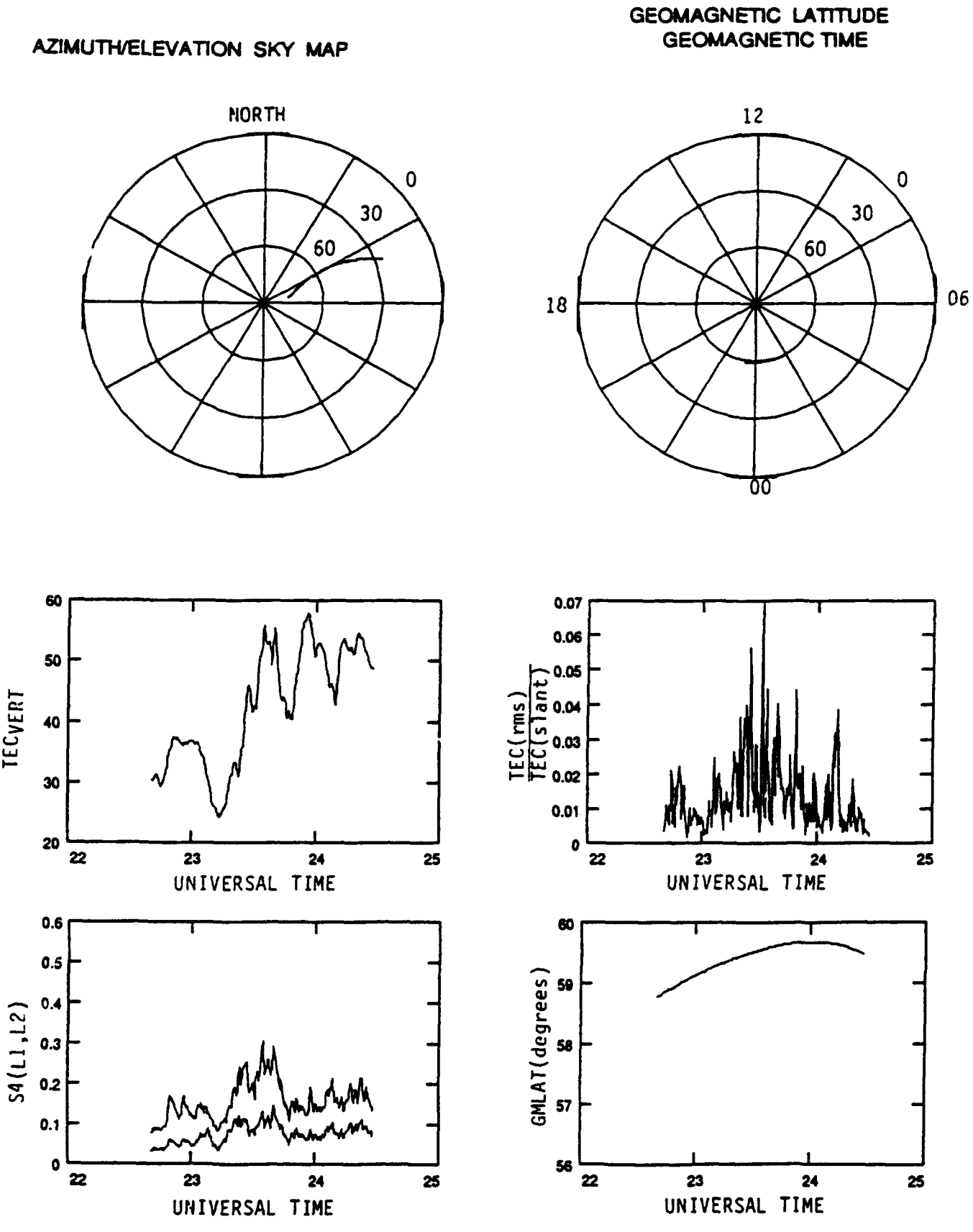


Figure 22. Graphical analysis of STEL-5010 Shetland data - Day 33.

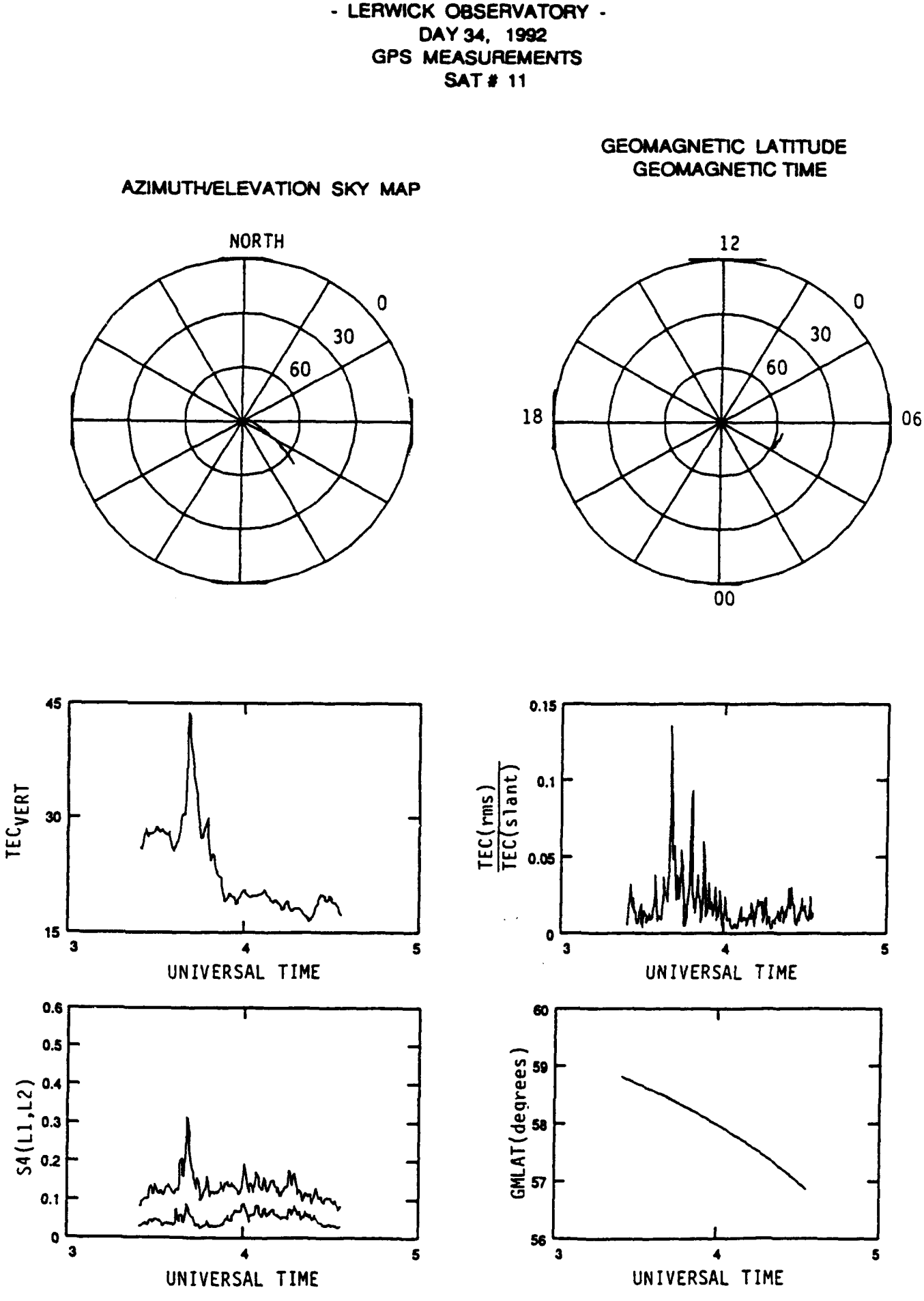


Figure 23. Graphical analysis of STEL-5010 Shetland data - Day 34.

- LERWICK OBSERVATORY -
DAY 57, 1992
GPS MEASUREMENTS
SAT # 3

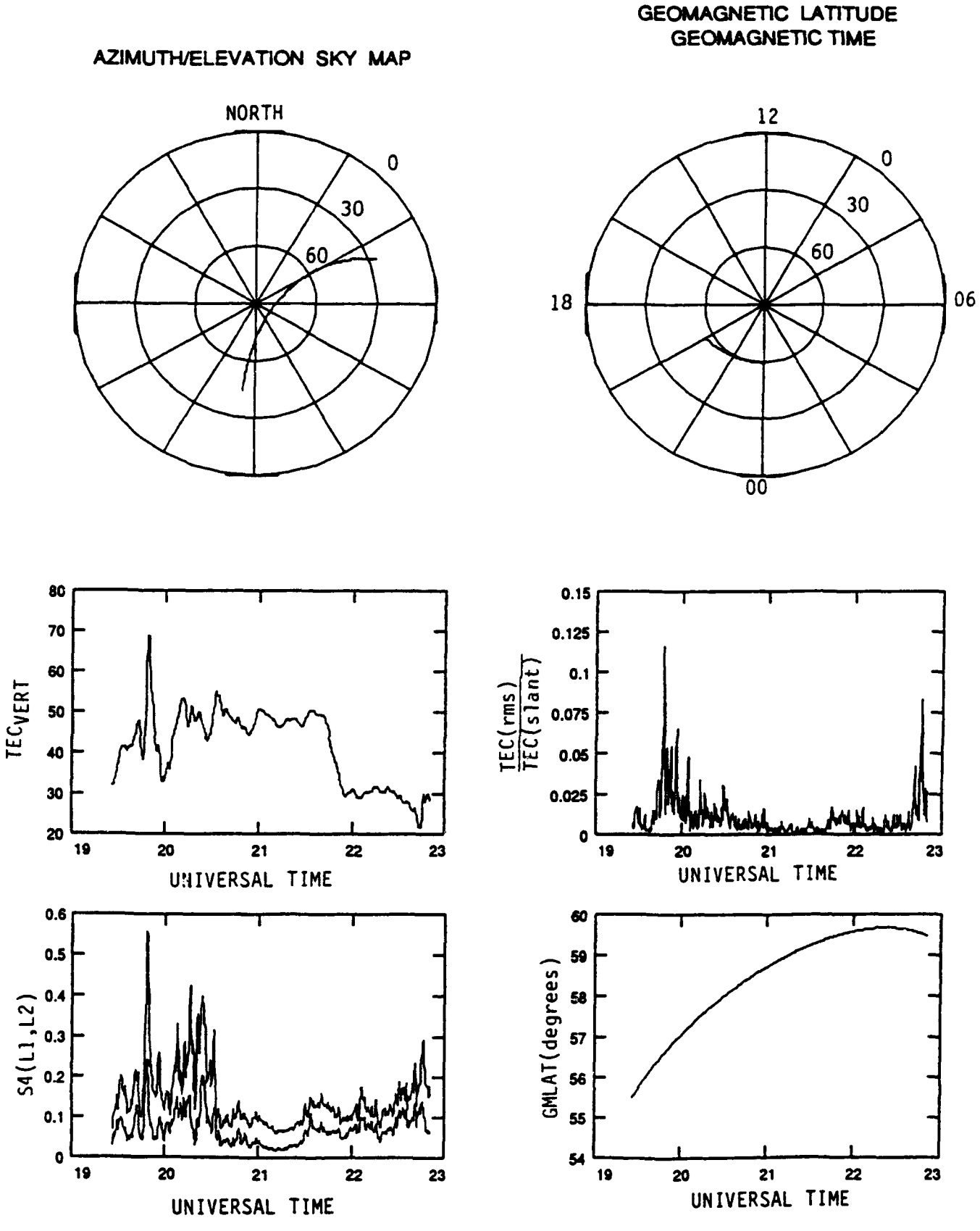


Figure 24. Graphical analysis of STEL-5010 Shetland data - Day 54.

- LERWICK OBSERVATORY -
DAY 60, 1992
GPS MEASUREMENTS
SAT # 3

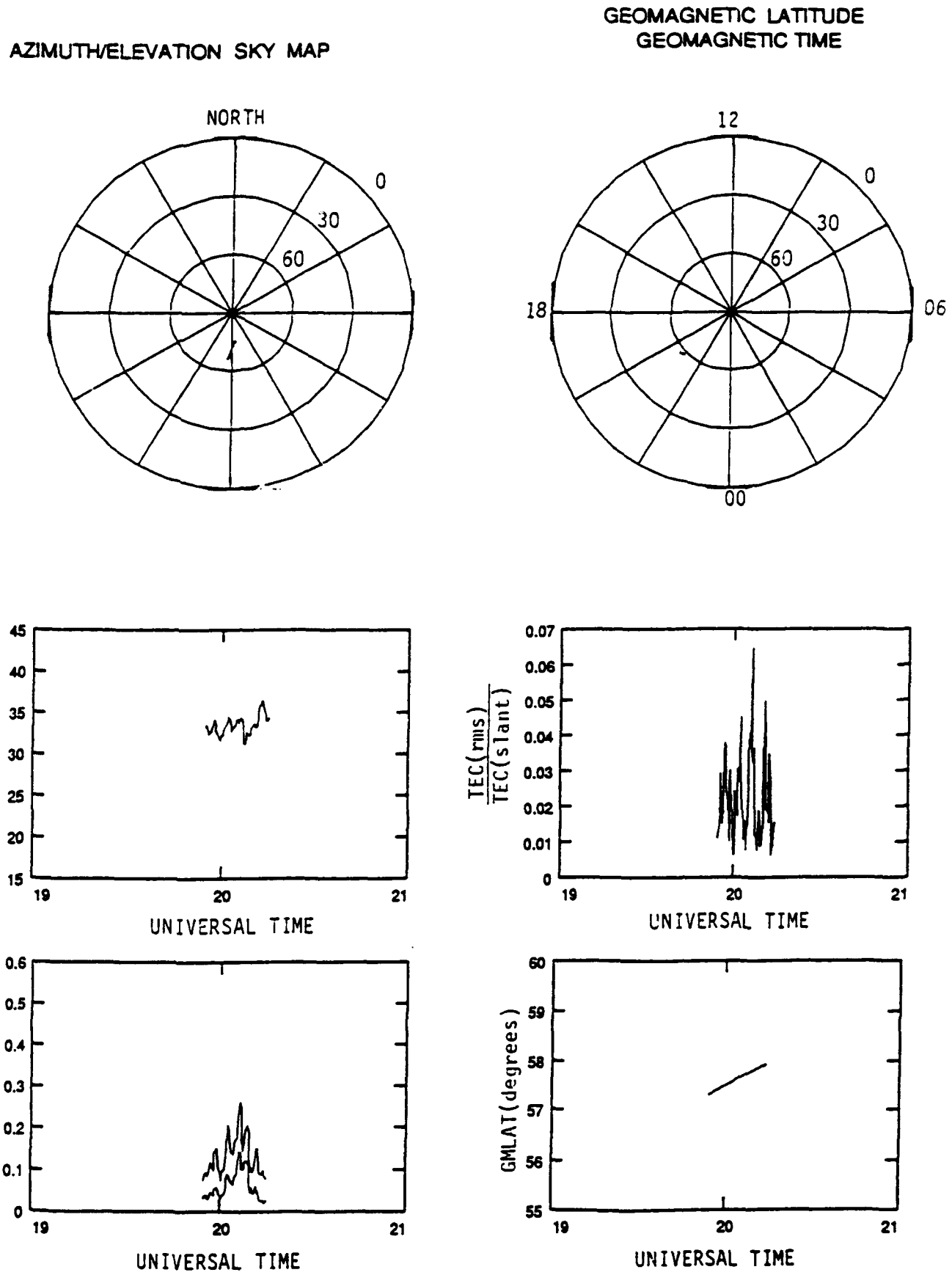


Figure 25. Graphical analysis of STEL-5010 Shetland data - Day 60.

- LERWICK OBSERVATORY -
DAY 60, 1992
GPS MEASUREMENTS
SAT # 13

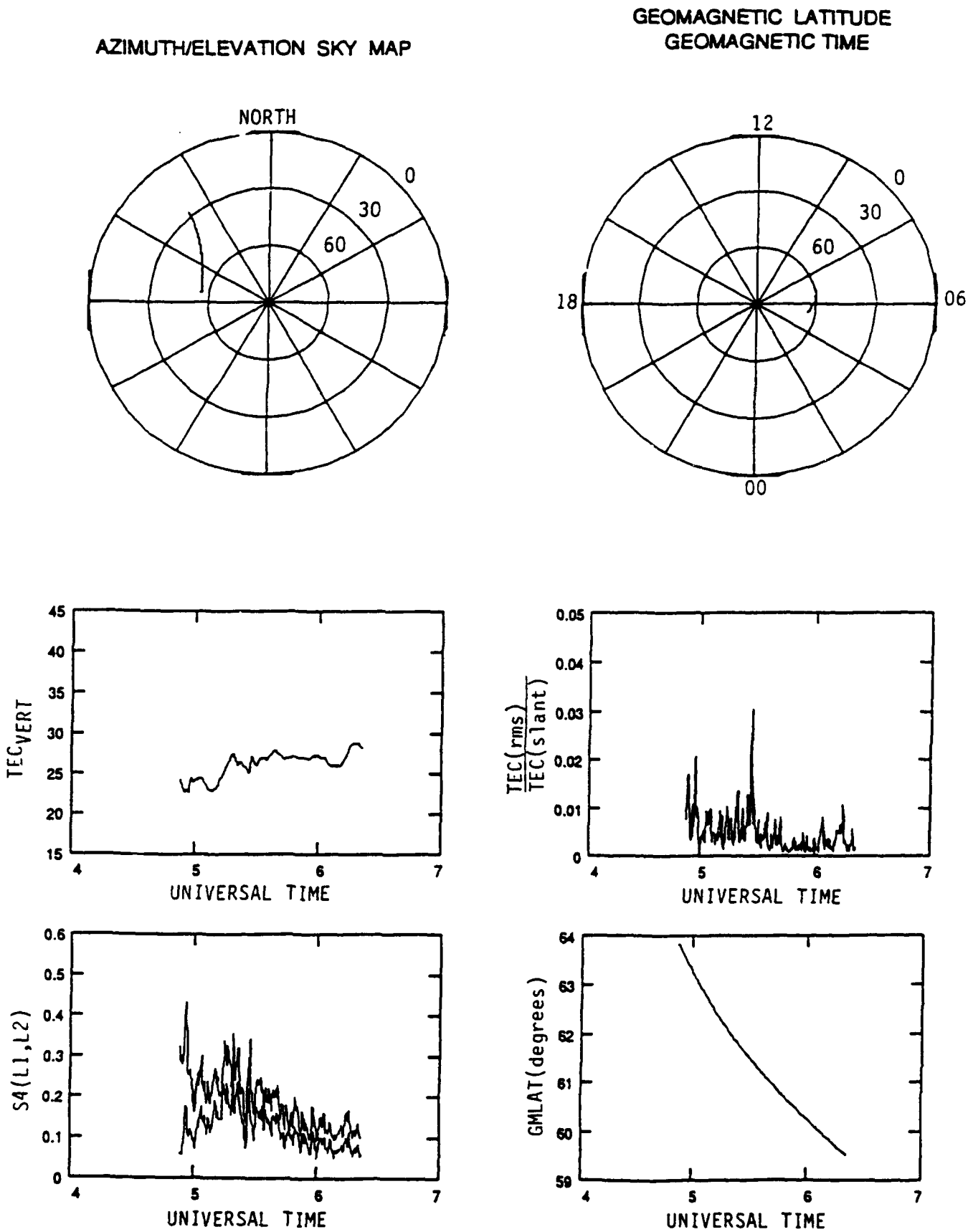


Figure 26. Graphical analysis of STEL-5010 Shetland data - Day 60.

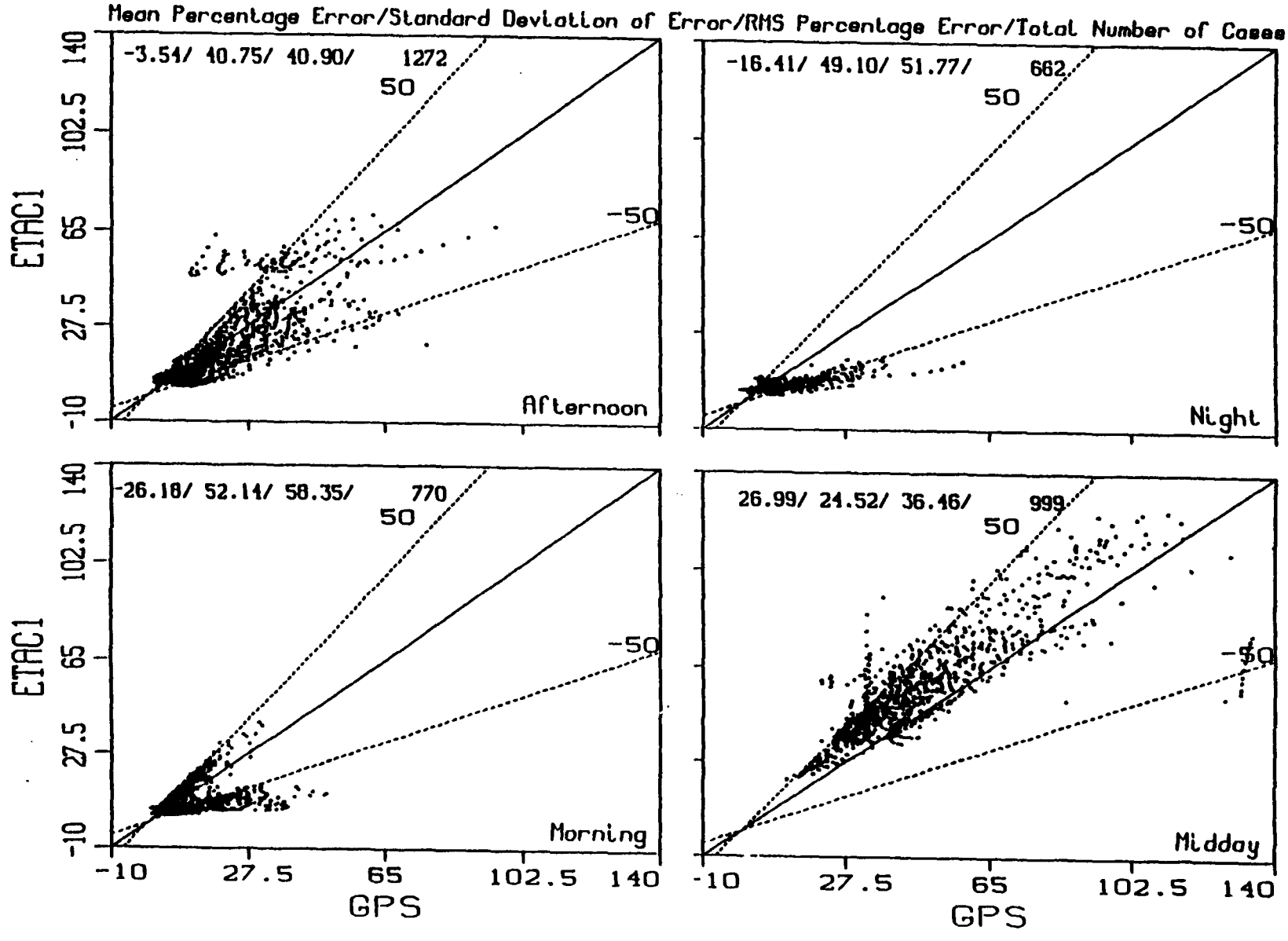


Figure 27. Comparison of Bent model predictions to measured TEC - Shetland December 1991 TI-4100 data - scatterplot.

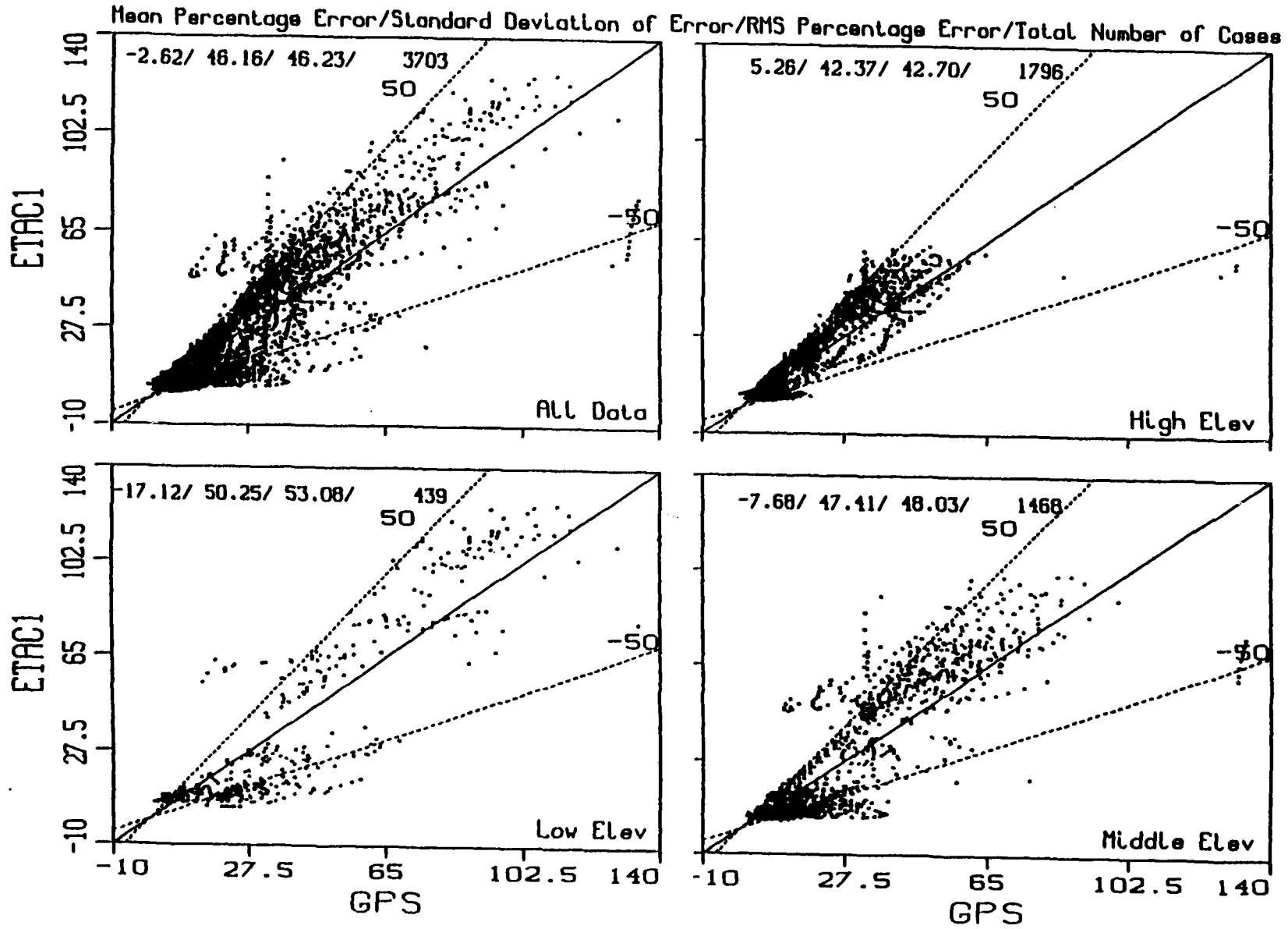


Figure 28. Comparison of Bent model predictions to measured TEC - Shetland December 1991 TI-4100 data - scatterplot.

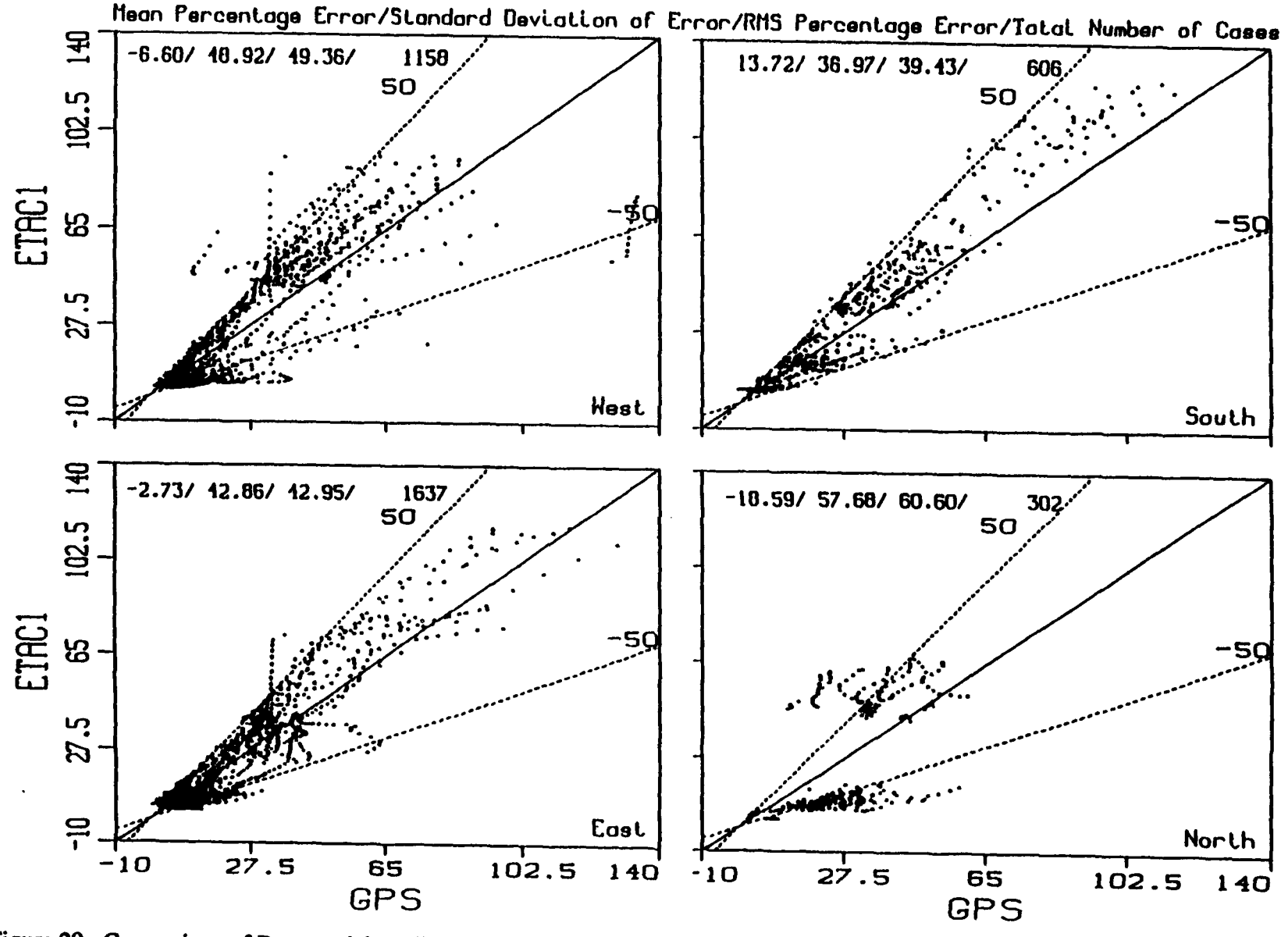


Figure 29. Comparison of Bent model predictions to measured TEC - Shetland December 1991 TI-4100 data - scatterplot.

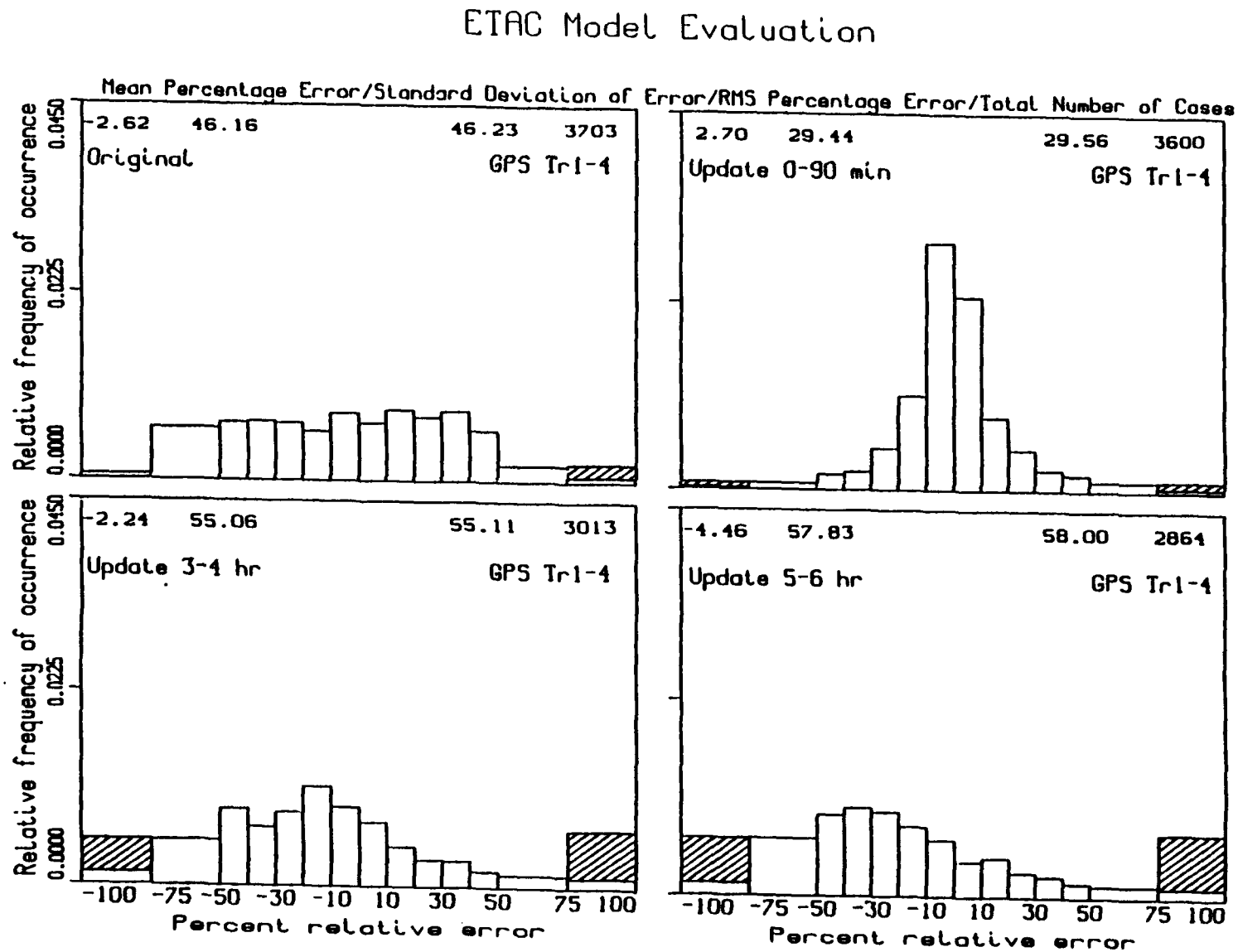


Figure 30. Comparison of Bent model predictions to measured TEC - Shetland December 1991 TI-4100 data - histogram.

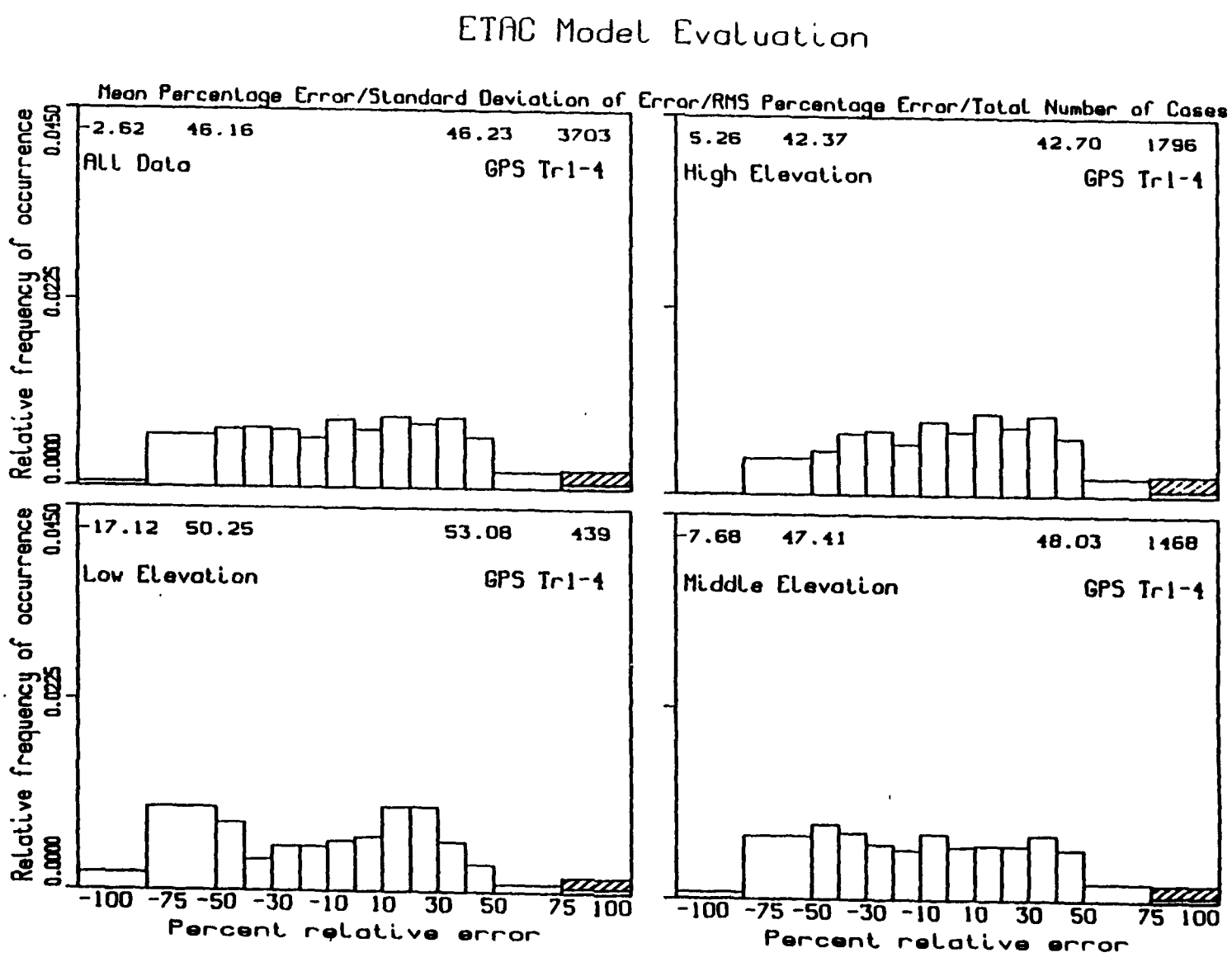


Figure 31. Comparison of Bent model predictions to measured TEC - Shetland December 1991 TI-4100 data - histogram.

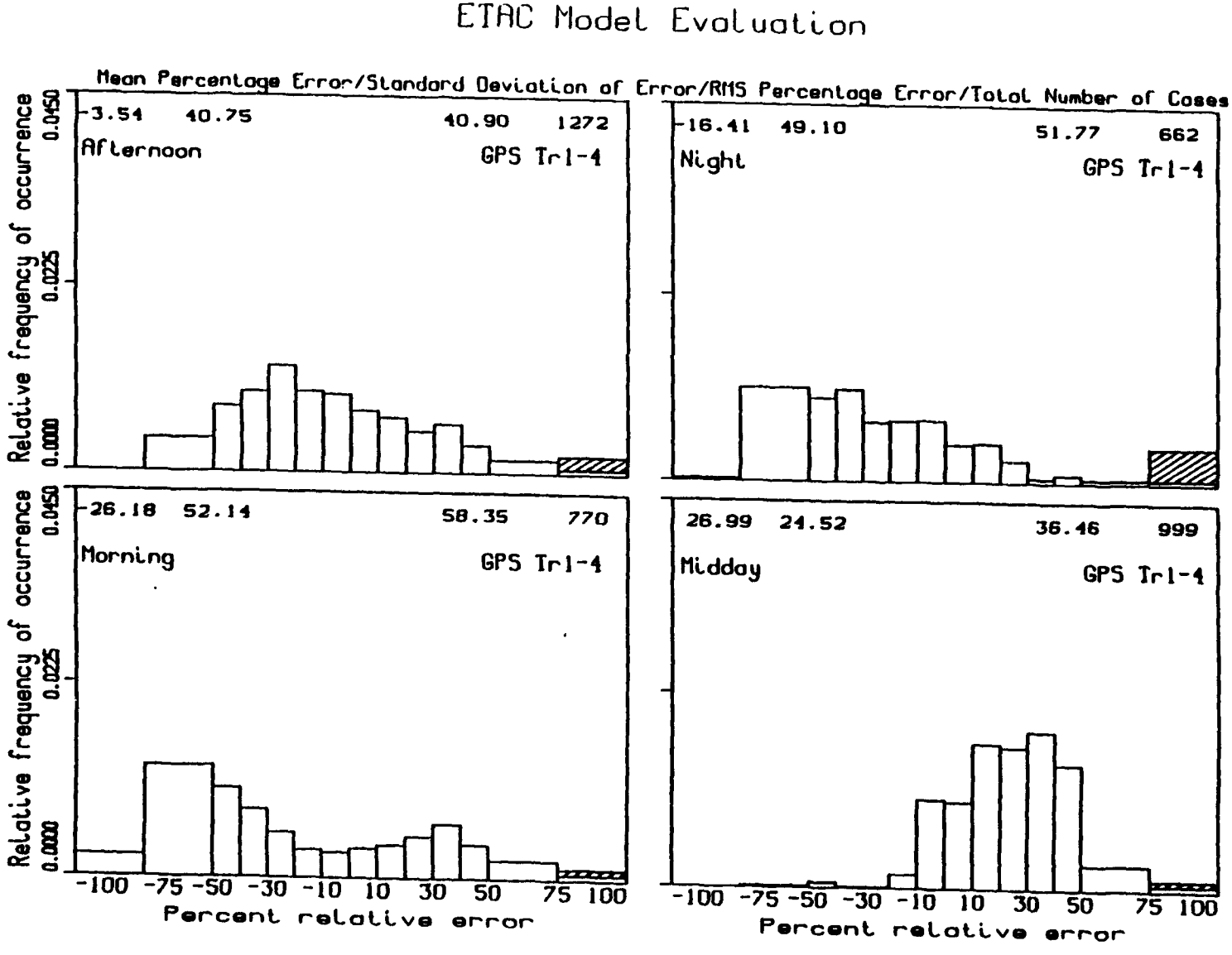


Figure 32. Comparison of Bent model predictions to measured TEC - Shetland December 1991 TI-4100 data - histogram.

F. Data Use in Scintillation Model

A potential use for measurements of the effects of the ionosphere on GPS signals is to use observations of ionospheric scintillation, both intensity and phase, to update a global model of ionospheric scintillation in near real time. The target model is the WBMOD ionospheric scintillation model presently in operational use by the USAF Air Weather Service (AWS). In order to use GPS-derived measurements of intensity and phase scintillation (as characterized by the S_4 and σ_ϕ indices and the T and p phase-spectrum parameters) it is necessary to convert the measurements into estimates of the height-integration strength of the electron-density irregularities which cause the scintillation, denoted C_kL. The C_kL estimates can then be used to modify the model of C_kL within WBMOD to provide an improved specification of ionospheric scintillation for AWS's use. The source of data will be the modified GPS receivers which will make up the AWS TISS planned for deployment in the mid 1990s.

Two programs have been developed and delivered to the AWS for this purpose. Program GBCKL (Ground-Based C_kL) converts TISS-derived measurements of T, p, S_4 and σ_ϕ to estimates of C_kL using the same single-regime power-law propagation theory used to calculate scintillation effects from C_kL in the WBMOD model. These estimates of C_kL, with estimates generated from *in situ* observations of the irregularities from the DMSP Scintillation Meter instrument, are used in program IONSAM to produce an analysis of the global distribution of C_kL for use in the WBMOD scintillation model. These two programs are part of the Ionospheric Scintillation Specification and Prediction System, which has been tested and installed at the USAF Space Forecast Center (AFSFC) at Falcon AFB, CO. Two versions of the IONSAM code were delivered, one that works within the DECWindows windowing environment and produces several displays and plots of the results of the analysis, and one with a simple command-driven interface which is capable of running on any system with a FORTRAN 77 compiler.

The software was formally tested at the AFSFC, and the results of the testing were documented in a Test Analysis Results document which was provided to AWS. The run times of the GBCKL and IONSAM program codes extracted from the test runs are summarized in Table 2. A TELSI record is a single data record which is to include a 15-minute summary of scintillation observations from a single TISS site. It can include data from up to four satellites. An SSIES record is a C_kL estimate generated from DMSP Scintillation Meter observations. During the testing period, the AFSFC personnel were given a briefing in which the analysis methods implemented in GBCKL and IONSAM were described, and guidelines for using the software to meet their needs were presented.

Documentation describing the use and structure of these two codes was also delivered to the AFSFC. Total documentation delivered included a Test Plan, a Test Analysis Report, two User Manuals (one for each program), and two Program Maintenance Manuals (one for each program). Copies of the documentation were sent to the AFSFC and to AWS/SCA (Capt. Jackson).

1. Program GBCKL:

   17-station, 24-hour run (6,370 TELSI records): 895s
   [2.2s per station-hour]

2. Program IONSAM:

   Data Input Section:

      3-hour TISS (3,570 data points) and SSIES (1,153 data points): 49s
      24-hour TISS (33,070 data points) and SSIES (8,642 data points): 351s

   Analysis Sections:

      Equatorial
         24-hour data set (10,086 data points): 2s

      Mid-latitude
         24-hour data set (4,126 data points): 1s

      High-latitude
         Startup: 2s + time of one iteration step
         Per iteration step:
            Non-binned (4,904 data points): 10s
            Binned (323 data bins): 0.8s

      Total for all three analysis sections for a typical analysis: 63s
         24-hour data set, equatorial section (10,000 data points)
         24-hour data set, mid-latitude section (4,000 data points)
         3-hour data set, high-latitude section (4,000 data points)
            Non-binned analysis, 5 iteration steps

Table 2. AFSFC testing - timing results.

IV. CONCLUSIONS

A large set of TEC and scintillation data has been collected from mid-latitude, sub-auroral, and polar stations over more than a year near solar maximum. The TEC data from the sub-auroral station (Lerwick, Shetland Island, UK) have been well analyzed and are shown to provide extremely detailed morphology for all times, seasons, and levels of magnetic activity. This data set includes four independent measurements in four different directions throughout the period, and techniques were developed to display these data to show the perspective of one monitor looking nearly overhead with two other monitors located north and south of the station. With this technique, latitudinal variations and motion of the ionospheric trough region were observed. It was seen that during periods of activity, in most instances coincident with time of high planetary Kp index, the observations are consistent with equatorward movement of the irregularity boundary. This conclusion supports earlier studies performed by other observers (Tsunoda, 1988). Although four-direction data were not available at the other sites, other data sets exist which may be studied in conjunction with the data obtained here. For example, concurrent 150- and 400-Mhz scintillation data were obtained at Shetland Island, and sounder data are available at Thule and Hanscom AFB.

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Secan, J. A., "Use of Apex Coordinate Transformation Tables," NWRA-CR-87-R020, Northwest Research Associates, Inc, Bellevue, WA, 1987.

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APPENDIX 1

ACTIVITIES SUPPORTING STATEMENT OF WORK FOR INVESTIGATION OF HIGH LATITUDE IONOSPHERIC STRUCTURES NEAR SOLAR MAXIMUM

During the 22-month study period, NWRA maintained and operated (or directed the operation of) data collection equipment at three sites: Thule AB, Greenland; Lerwick Observatory, Shetland Island, UK; and Hanscom AFB, MA. The GFE operated and serviced by NWRA consists of STEL-5010 single-channel GPS receivers, a TI-4100 four-channel GPS receiver, MX-1502 Transit receivers, and a NIMS code-free, multi-channel, GPS receiver manufactured by AIR.

The STEL-5010 located at Shetland Island experienced many failures during this study period. Many resources, both financial and manpower, were expended to maintain the site in an operating condition. This impacted the quantity and quality of data that were collected at the Shetland Island site as well as the amount of data from all sites that were processed. Emphasis was placed on the reduction of TI-4100 four channel GPS Shetland Island data, which are applicable to the BMEWS radar at Fylingdales, UK.

The STEL-5010 single channel GPS receiver at Hanscom failed on 2 November 1991. Repair was attempted using parts from the spare STEL-5010 receiver. The spare receiver, having been used for parts several times, contained no usable cards, and repair of the Hanscom receiver could not be accomplished. The spare receiver was sent to STEL for repair. Several months later, a repair estimate was received from STEL that was rejected by AFPL as too costly. In view of the cost vs. benefits analysis, the receiver at the Hanscom site was not repaired.

An MX-1502 Transit receiver remained in operation at Hanscom AFB. This receiver provides latitudinal relative TEC profiles from north-south traveling satellites of the NNSS. In order to determine actual TEC levels, these data require that complementary absolute TEC data be used to calibrate the relative TEC measurements, as was done for UCW Transit data. Data are available from this geographic location that could be used for such a calibration process. From January 1991 through June 1992, data from a geostationary satellite were collected using a polarimeter located at Hamilton, MA. These data can be requested through Mr. Jack Klobuchar at AFPL/GPIM, Hanscom AFB, MA, 01731-3010. Ionosonde data collected at Millstone Hill, MA, are available in several different formats from World Data Center, Boulder, CO, and could also be used as reference. (Ionosonde data, collected during the contract period, with approximately 90 percent yearly coverage, is also available from Qânâc, Greenland, and Narssarssuaq, Greenland.)

During the 22-month study period, NWRA maintained and operated (or directed the operation of) a variety of satellite receivers at Hanscom AFB, MA; Lerwick Observatory, Shetland Island, UK; and Thule AB, Greenland. The near solar maximum database in Appendix 4 details the availability of data according to date, site, and receiver type, and indicates the level to which these data have been processed and the quality of that processed data. The following is a chronology of the problems and repairs that were experienced.

22 December 1990 Shetland : STEL-5010 receiver failed. Repaired during the next scheduled service trip on 19 February 1991.

7-21 January 1991 Thule : Due to logistical problems associated with the Gulf War, delivery of data tapes to Thule ABwas not possible, and consequently no data were recorded for 40 days during the period 11 January 1991 to 20 February 1991.

18 January 1991 Hanscom : Calibration performed on the STEL-5010 system.

19 February 1991 Shetland : A faulty L2 microwave oscillator was identified as the source of the problem. Replaced with a similar oscillator from test transmitter until arrival of a permanent replacement. Part arrived at Shetland on 5 March 91 and was installed. New 5v power supply installed in GPS receiver. A calibration and tune up was successfully performed on the repaired receiver. Regular maintenance performed on the TI-4100 GPS receiver.

4 April 1991 Shetland : STEL-5010 receiver failed.

13-21 May 1991 Thule : Service trip to field site. Calibration performed.

26 May-2 June 1991 Shetland : Service trip to field site. GPS receiver repaired using parts from a spare receiver sent up as a replacement for old receiver. Spare receiver inoperable due to rough handling during shipping. A complete calibration of the STEL-5010 was performed. Regular maintenance performed on the TI-4100 GPS receiver.

15 July 1991 Hanscom : Magnavox MX-1502 receiver returned to AFPL from ARL-UT. Installed for test period of two months before being deployed to Shetland Island during next service trip.

20 July 1991 Shetland : A loose cable connection was detected when data from site were processed. It was traced and temporarily fixed by site personnel until the next scheduled maintenance trip. Also, the system printer exhibited intermittent failure, causing the entire data collection system to halt. Operator intervention was necessary to restart the system after such a failure.

2 November 1991 Hanscom : The STEL-5010 receiver failed. The problem was traced to the antenna pre-amp switch that was found to be half full of water. This shorted out the amplifiers in the pre-amp and caused some internal problems in the receiver. Repair was deferred until the return of the spare STEL-5010 receiver from STEL.

4-11 November 1991 Shetland : Service Trip to field site. Equipment serviced, calibration performed, and the MX-1502 Transit receiver installed. The STEL 5010's antenna was relocated from the roof to within 40 feet of the TI-4100's antenna using 400 feet of low-loss antenna cable. Regular maintenance performed on the TI-4100 GPS receiver.

8 February 1992 Shetland : The TI-4100 receiver was turned off and shipped back to ARL-UT for calibration and reprogramming before deployment to Shemya, AK, on another effort.

8-12 March 1992 Thule : Service trip to field site. Calibration performed. Plexiglas dome on the antenna was found destroyed and a temporary fix implemented while replacement was sought.

17 March 1992 Shetland : The VT-103 video display on the GPS receiving system failed. Data collection continued while a replacement display unit was sent.

02 April 1991 Hanscom : A new multichannel GPS receiver from AIR was received for testing. It was found to have several defects and was returned to the manufacturer for repair.

15 July 1992 Shetland : Data collection halted due to a dead blower motor on the Cipher tape drive. Replacement tape drive was sent, but system was still inoperable due to the need for a complete system tune up. A decision was made at AFPL/GPIA to shut down the STEL-5010 GPS receiver system due to cost and time involved in getting the system back in working order.

APPENDIX 2

QUALITY ASSURANCE EFFORTS FOR DATA ACQUIRED IN THE INVESTIGATION OF HIGH LATITUDE IONOSPHERIC STRUCTURES NEAR SOLAR MAXIMUM

In order to determine TEC values accurately, the measurement contributions of satellite biases and receiver offsets must be considered. The error introduced by the receiver can, in the case of the STEL-5010 single-channel receiver, be determined by a calibration process. This is accomplished by injecting a known signal from a test transmitter directly into the receiver system at the pre-amp and measuring the response in volts. Attenuators are inserted between the test transmitter and the pre-amp. Attenuation is increased until the receiver begins to lose lock on the weak signal. The attenuation level is backed off 30 dB. Several steps of delay are then introduced and the corresponding receiver response is measured. From this set of input dB of attenuation and output voltages, a linear relationship is determined. This calibration is used in the processing of the raw data in the programs GPSPCNW3.FOR and GPSPC3.FOR. Each recorded voltage measurement is converted to dB of attenuation according to the linear relationship determined by the calibration. The process in repeated for both the L1 and L2 channels.

A calibration is also done on the DGD output. Signal delay is introduced in 6 NS (1NS = 2.852 TEC) steps through a range of 278.83 TEC, and the output of the DGD channel is measured. This set of inputs and outputs produces a best-fit linear relationship, which is applied to the raw data measurements by the programs GPSPCNW3.FOR and GPSPC3.FOR to determine the actual values of DGD.

In addition to the calibration adjustments to the raw TEC data, an adjustment is also made to correct for satellite biases. Satellite biases are the result of the actual delay between the L1 and L2 signal transmissions from the satellite. This correction is applied by removing the bias values from slant TEC measurements during processing through GPSPCNW3.FOR and in the plotting programs before conversion to equivalent vertical TEC.

Plotting of the data provides a quality check on the collection equipment's performance. Several programs, described in Appendix 3, are available to plot the data as 24-hour profiles, 24-hour several-day overplots, and individual satellite passes. The azimuth and elevation of the satellite can be displayed on the pass file plots, while satellite latitude and longitude can be shown with the 24-hour format plots.

While processing the December 1991, January 1992, and February 1992 data from Shetland Island, it was noted that the 24-hour TEC profiles exhibited negative values and distortion which might be attributable to incorrect values of satellite biases and receiver offset being used by the plotting routines Vertec3.for (single-channel data) and Vertec4.for (4-channel data).

An analysis was undertaken to find values for satellite biases and receiver offset that would yield TEC curves having reasonable shape and minimum TEC level. First, several weeks of single-channel data were overplotted in one-week sets. The assumption was made that receiver offset and satellite biases were approximately constant over this period. The character of the TEC

curves, with respect to expected behavior, was examined. Changes to receiver offset and individual satellite biases were estimated. The data were rerun using the revised values and analyzed again. The several week period (three months) allowed examination of most satellites during some nighttime hours, due to the satellites appearing approximately four minutes earlier each day. The conversion to equivalent vertical produced distorted data when the combined satellite bias and receiver offset were incorrect, guiding the revised estimate for the next iteration. This process was repeated until an offset and a set of bias figures for the block-1 satellites that resulted in reasonably shaped TEC curves were determined.

Four-channel GPS data from the same time period and site were studied next. Using the block-1 satellite biases determined from the single-channel data, the four-channel data were analyzed to select a receiver offset that resulted in similar TEC profiles for the same satellites at the same times as the single channel. Once this was done, the biases for block-2 satellites were estimated by referencing a block-2 satellite at a given latitude, longitude, and time to a block-1 satellite at very nearly the same latitude, longitude, and time. The data were reprocessed, refining the biases each time. After several iterations, the estimated values of receiver offset and satellite biases produced 24-hour plots of TEC whose behavior exhibited expected diurnal and seasonal variations, no negative TEC values, and credible minimum levels. Table 3 lists the empirically derived satellite bias values.

Table 3.
Derived Satellite Biases

Satellite No.	Bias Value (TECu)	Satellite No.	Bias Value (TECu)
2	2.20	15	1.96
3	10.67	16	7.77
6	7.33	17	2.75
8	0.00	18	-3.99
9	-0.97	19	7.76
11	18.01	20	2.59
12	10.41	21	17.54
13	10.73	23	3.60
14	2.04	24	5.00

In order to evaluate the accuracy of these empirically determined offset and bias values, several single-channel data sets were overplotted using offset values which varied by steps of +/-2 TEC. These data sets are shown in Figures 33 -35. It can be seen, in Figure 35 particularly, that very little change from the empirically derived bias values begins to introduce distortion in the TEC curves, indicating that the accuracy of these values is about ± 2 to 3 TEC units.

This set of bias values determined on the basis of December 91, January 92, and February 92 data proved to be valid for data back to March 91 and ahead to March 92. It should be noted that the four-channel 1991 data showed a gradual, overall shift in level of the TEC curves. This is believed to be caused by a drift in the TI-4100 receiver due to aging of components. The receiver seemed to be stable over certain time periods, ranging from one week to three months, and an appropriate offset was determined for each of these periods using the procedures described above.

For days 060 - 174, 1991, the offset was determined to be -5.91 TECu; days 175 - 230, 1991, the offset was -10.91; days 231 - 237, 1991, the offset was -15.91 TECu; and for days 247, 1991 through 039, 1992, the offset was -20.91 TECu. The single-channel receiver offset was determined to be -16.0 TECu.

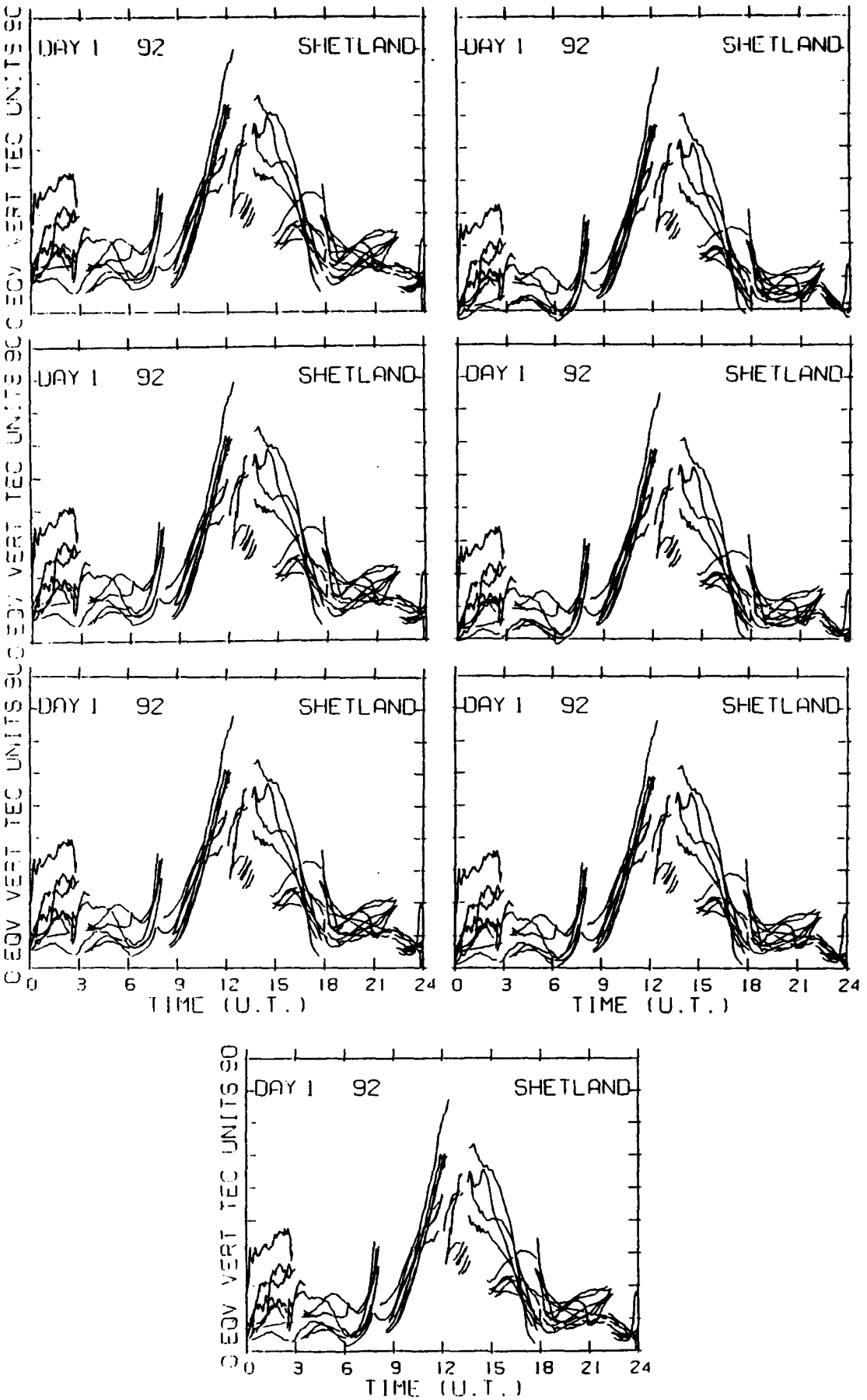

Figure 33. Satellite bias accuracy analysis - Day 01 1992.

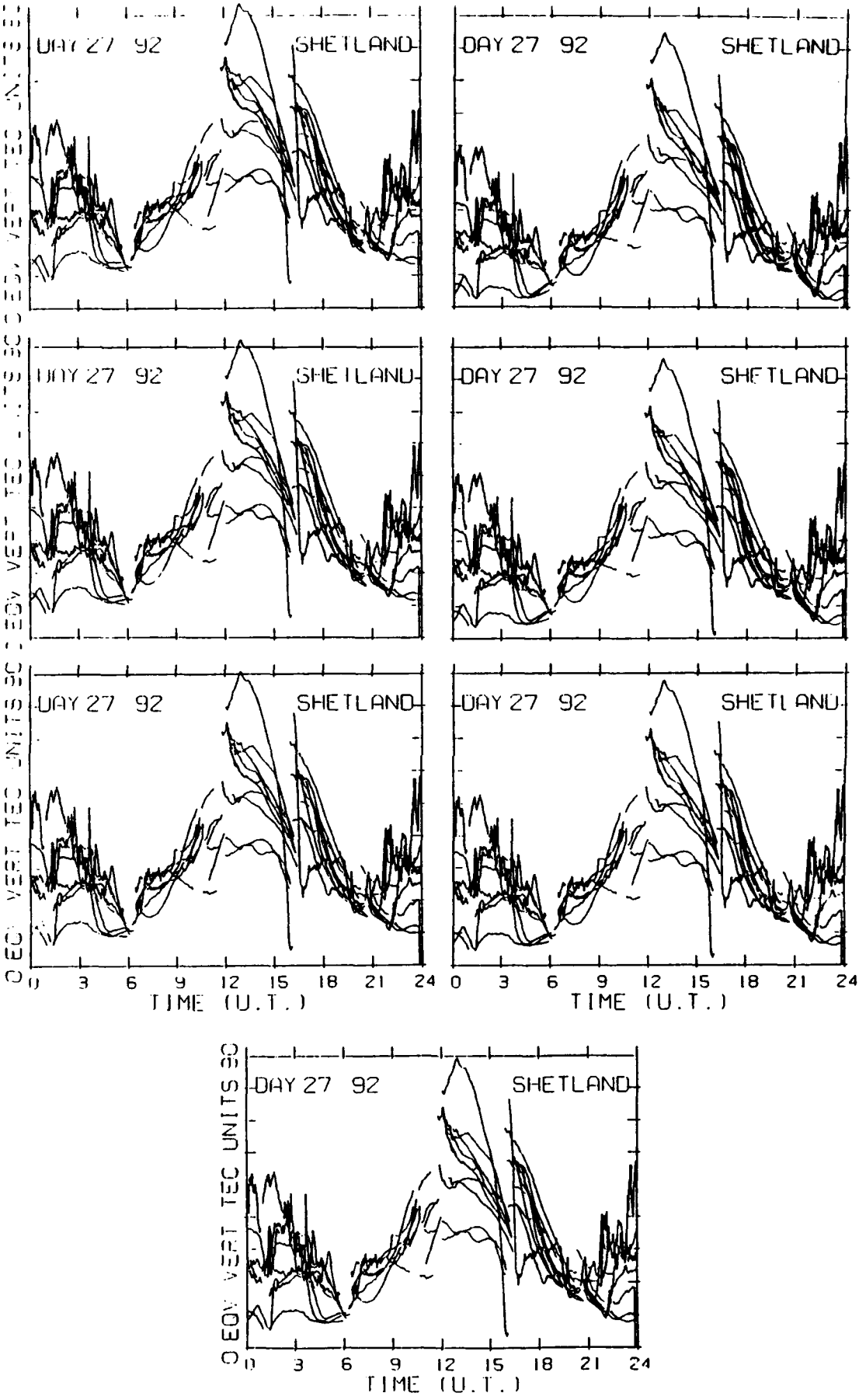

Figure 34. Satellite bias accuracy analysis - Day 16 1992.

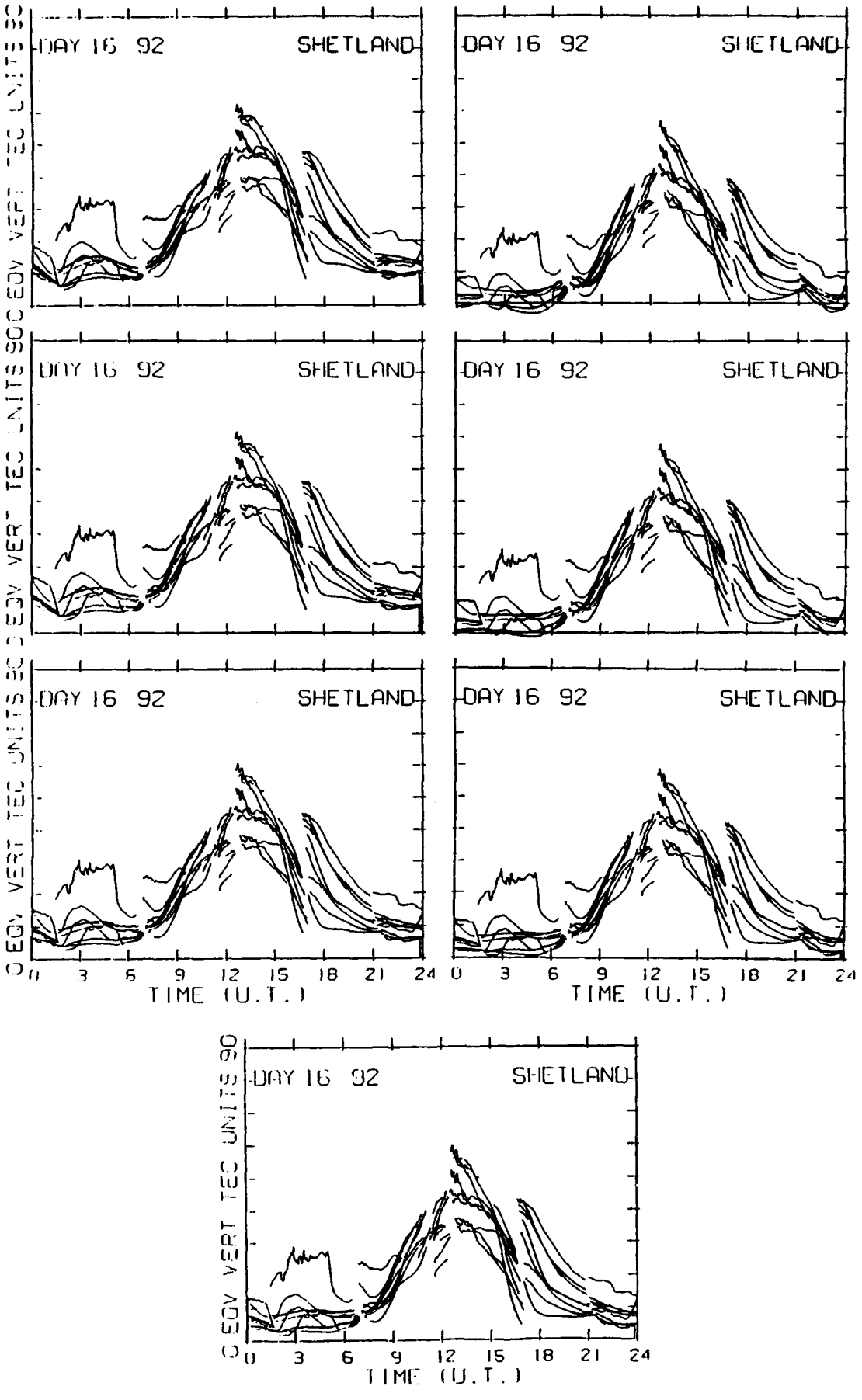

Figure 35. Satellite bias accuracy analysis - Day 27 1992.

APPENDIX 3

DESCRIPTION OF SOFTWARE FOR REDUCTION AND ANALYSIS OF NEAR SOLAR MAXIMUM HIGH LATITUDE DATABASE

The software developed during this effort reduces the raw data to files from which 24-hour plots, several-day overplots, pass-file plots, latitude-separated plots, and IPP-adjusted time plots of equivalent vertical TEC are produced. These programs can be used with any GPS data, such as that collected by the planned TISS, in the same manner as they are used with the NWRA database: to test, quality check, reduce, analyze, and display the data.

The programs developed for this study are written in FORTRAN for use with Microsoft FORTRAN for PC and are described in the following text. The following information is organized by site and receiver type. Programs to process data collected by the same receiver type at different sites will only be shown with an underscored title.

A. SHETLAND ISLAND, UK

During the period of study, three receivers were operated at the Shetland Island site: an STEL-5010 single-channel GPS receiver, a TI-4100 four-channel GPS receiver, and an MX-1502 Transit receiver.

1. STEL-5010 Single-Channel GPS Receiver

The STEL-5010 single-channel GPS receiver collected data from Block-1 GPS satellites and recorded the data on 10-inch magnetic tapes. Each tape holds approximately 48 hours of data. DGD between L1 (1575.4 Mhz) and L2 (1227.6 Mhz), DCP between those two signals, and the received intensities of the L1 and L2 signals were recorded at 20 Hz as binary files. The following programs are used to process these data.

a. GPSPCNW3.FOR

Input to this program is the raw STEL-5010 GPS data from the 10-inch tapes. This program can be used on all data taken with the STEL-5010 receiver from any site and any year. The output is an ASCII file containing a table that lists universal time (seconds), intensity scintillation (S4) at L1 and L2 , slant TEC, rms DCP, azimuth and elevation angle of the satellite from the ground station, geomagnetic latitude, geomagnetic longitude, geomagnetic time, and the penetration angle at the 350 km IPP. A header at the beginning of the file lists the GPS satellite ID number, Julian date, year, and the name of the receiving site.

The data are one minute averaged values listed every 20 seconds. Geometry data and the time values correspond to the center of the one-minute averaging interval. The RMS DCP data represent a measure of the standard deviation in dispersive phase. The values listed are RMS values of TEC units over a one minute averaging interval that were obtained using data from the

deramped Doppler channel. It should be noted that the deramped Doppler is equivalent to relative TEC.

The following subroutines are used and are described as follows:

SUBROUTINE RMSPHI

Data from the deramped Doppler channel are processed to obtain one-minute average RMS values which are written to an intermediate file.

SUBROUTINE NAV12

Time and measurement data consisting of one-minute averages at 20 seconds increments are read from an internal file and stored in memory. Keplerian elements applicable to the GPS satellite being tracked, measured time and station geodetic coordinates are input to subroutine NAVSTAR. NAVSTAR returns the azimuth and elevation of the satellite at the ground station and the geodetic coordinates of the satellite latitude and longitude. NAVSTAR was originally a pass planner that produced files containing the described geometry information for all GPS satellites observable from a specified ground station at 10 minute increments. The modified NAVSTAR subroutine enables the user to directly obtain the necessary geometry information without having to access external files, thereby circumventing an additional processing procedure that otherwise would be critical.

SUBROUTINE MAGIPP(QNAME4)

MAGIPP is a geometry conversion program that inputs receiver coordinates, measurement time (UT), and the outputs obtained from NAVSTAR as described above, and produces an intermediate file containing penetration angle, geomagnetic latitude and longitude, and geomagnetic local time all referenced to the 350 km IPP. In accomplishing this task an additional subroutine, IPP, is used that calculates the latitude and longitude of the IPP, given the receiver location and azimuth and elevation look-angles to the satellite.

PROCESSING ERROR INFORMATION

During routine data processing, errors detected are written to disk on file geomN_err where N is incremented for each run (1-9 range).

Error conditions identified are as follows:

1) almanac data necessary for updating the Keplarian elements are identified
2) almanac data on file is out-of-date by a specified number of days
3) almanac data file does not match the requested satellite ID
4) elevation angle below the horizon
5) almanac data file has bad format
6) failure of the Kepler subroutine to converge

b. GPSPC3.FOR

This program is used to process the raw STEL-5010GPS data stored as 20 Hz binary data on the 10-inch tapes. It generates four ASCII data files containing DGD and DCP, as six-second averaged values, and intensity scintillation, S4(L1) and S4(L2), as one-minute averaged values, calculated every 20 seconds. These files are the inputs to the plotting routines.

c. SHTREC2.FOR

Shtrec2.for phase averages the DCP data using the DGD as reference. Inputs to this program are the DGD and DCP files created by GPSPC3.FOR. Outputs are files in the same six-second format containing phase averaged DCP and the unaltered DGD data. These files become the inputs to the plotting programs.

d. VERTEC3.FOR

Vertec3.for produces plots of the DGD and DCP data. The user can select the format of the plot to be either a 24-hour equivalent vertical TEC profile, a 24-hour overplot of several days of equivalent vertical TEC, or individual pass files for each satellite in a data set. The pass file plots can display slant TEC from DGD, slant TEC from DCP, and vertical TEC from phase-averaged DCP on one plot.

Inputs to Vertec3.for are the two files generated by the Shtrec2.for program and a file containing satellite ephemeris data, called the AZ-EL file, which is created using the RUNELEM.BAT process. The output is a 24-hour plot or pass-file plots, as selected by the user.

For Shetland Island STEL-5010 single-channel data only, a file containing a table of equivalent vertical TEC and IPP latitude and longitude at five-minute intervals is also generated by Vertec3.for. These tables are sent to UCW for use in calibrating their Transit satellite data. In turn, the calibrated Transit measurements become the input to the Transit Analysis statistical evaluation software package, described below.

e. VERTEC4B.FOR

Essentially the same as Vertec3.for, this program can also plot the data according to IPP adjusted time, as opposed to UTC.

f. PLTS424.FOR

This program plots the S4 files, calculated from L1 and L2, generated by the GPSPC3.FOR program as 24-hour plots or individual satellite pass plots.

g. TRANSIT ANALYSIS SOFTWARE PACKAGE

RDP, Inc. of Waltham, MA, has created software to evaluate the ETAC ionospheric model (based on the Bent ionospheric model). Transit data from UCW that have been referenced to the GPS data collected at Shetland Island and processed by NWRA, are compared to model predicted values and a statistical analysis is performed. This software was modified to also accept as input single channel-format GPS absolute TEC data from the TI-4100 receiver.

h. RUNELEM.BAT

The purpose of this batch file is to create the AZ-EL file containing the satellite ephemeris data needed by the plotting programs. The files needed by this process are; (1) an almanac file from the Holloman AFB bulletin board covering the period of time of interest, (2) a site file containing the name, latitude, longitude, elevation of the site, and the start/stop Julian dates of the desired az-el coverage, and (3) the programs Gpselem.for and Nav11.for. The output is an az-el file containing the ephemeris data needed for plotting.

1. GPSELEM.FOR

Gpselem.for reformats the almanac downloaded from the Holloman AFB bulletin board so that it can be used by the Nav11.for program.

2. NAV11.FOR

Nav11.for produces an az-el file that contains the azimuth, elevation, latitude, and longitude of each satellite at 10 minute intervals, for each day in the period specified in the site file.

i. PLTREC7C.FOR

This utility program allows for manual correction of discontinuities in the phase data (DCP) that is in the single-channel (STEL 5010) file format. With the data graphically displayed on the screen, the operator uses the cursor to mark the discontinuity. The program will remove the discontinuity by connecting the discontinuous data and changing the data values appropriately.

2. TI-4100 Four-Channel GPS Receiver

A TI-4100 four-channel receiver was located at Shetland Island from 1 April 1990 to February 1992. The data are recorded on a DC2000 40 MB tape cartridges at a sampling rate of 1 Hz. Software to process these data was written by ARL-UT for the CYBER mainframe computer, which was decommissioned in August 1992. Most of the 1991 data were converted from original format to a single-channel format, i.e., the STEL-5010 data format, so that they could be analyzed and plotted in the same manner as the single-channel data for ease of comparison. Because the DCP data experience many drop outs and are therefore not readily suitable for the phase-averaging process without discontinuity correction using the labor intensive Pltrec7c.for process, the DGD data only are plotted as equivalent vertical TEC.

a. SHTREC4.FOR

This program is similar to the Shtrec2.for. It performs the phase averaging process and generates intermediate files which are the inputs to Vertec4.for, the plotting program. If the DCP data have been corrected for discontinuities using Pltrec7c.for, then equivalent vertical TEC can be generated from the DCP. If discontinuity correction has not been performed, Vertec4.for can produce plots of equivalent vertical TEC from DGD only. Each of the four trackers is processed separately.

b. ERTEC4.FOR

The output files from Shtrec4.for become the inputs to Vertec4.for. Also needed as input is the AZ-EL file containing the satellite ephemeris data from the time period of the data to be

plotted. In response to the program's questions, the user determines whether the output is a plot of equivalent vertical TEC which is derived from DCP, if the DCP has been corrected for discontinuities using Pltrec7c.for, or a plot of equivalent vertical TEC from DGD only. Twenty-four-hour plots, individual pass file plots, or several days overplots of data can be produced in order to validate the data or study TEC behavior over a specific time period. Each of the four trackers is processed separately.

A file containing equivalent vertical TEC, and IPP latitude and longitude at five minute intervals is also generated by Vertec4.for. These tables are sent to UCW for use in calibrating their Transit satellite data.

c. SHETDIR4.FOR

The data from all four trackers for a given day can be plotted according to latitude regions using Shetdir4.for. This program inputs the absolute TEC (DGD) files for a specified day, or series of days, and produces 24-hour plots of the data from the selected latitude region; north, overhead, or south with respect to the receiving station. This is helpful in discriminating between the mid-latitude/trough and auroral/polar cap behavior. Data can be plotted versus universal coordinated time or IPP adjusted time.

3. MX-1502 Transit Receiver

a. MX2IP.BAT

ARL-UT has provided a software package to process the data recorded by the MX-1502 receiver. The MX2IP.bat file reads the data from the data cassette and generates an ASCII data file in ionospheric parameter format containing observing station information, satellite information, time, refraction count, change in TEC from last time to current time, signal strength, azimuth, and elevation. The data can be plotted using the Ipplot program.

B. THULE AB, GREENLAND

One STEL-5010 single-channel GPS receiver was operated at the Thule AB, Greenland.

1. STEL-5010 Single-Channel GPS Receiver

a. GPSPCNW3.FOR

b. GPSPC3.FOR

c. SHTREC2.FOR

d. VERTEC3.FOR

e. VERTEC4B.FOR

f. PLTS424.FOR

g. *RUNELEM.BAT*

1. GPSELEM.FOR

2. NAV11.FOR

h. PLTREC7C.FOR

C. PHILLIPS LABORATORY, HANSCOM AFB, MA

Three receivers were in operation at PL during the period of study; an STEL-5010 single-channel GPS receiver, an MX-1502 Transit receiver, and an NIMS nulti-channel GPS receiver manufactured by AIR. The AIR receiver was acquired in APRIL 1992 and shortly thereafter returned to the manufacturer for repair. In a letter from AIR dated 27 July 1992, it was reported that the receiver fails to meet specified accuracy levels due to antenna design problems which they plan to correct. Therefore, the data from this unit is necessarily of doubtfull quality due to this design flaw.

1. STEL-5010Single Channel GPS Receiver

a. GPSPCNW3.FOR

b. GPSPC3.FOR

c. SHTREC2.FOR

d. VERTEC3.FOR

e. VERTEC4B.FOR

f. PLTS424.FOR

g. *RUNELEM.BAT*

1 GPSELEM.FOR

2. NAV11.FOR

h. PLTREC7C.FOR

2. MX-1502 Transit Receiver

a. MX2IP.BAT

APPENDIX 4

NEAR SOLAR MAXIMUM HIGH LATITUDE DATABASE

Data were collected at three sites: Thule AB, Greenland; Lerwick Observatory, Shetland Island, UK; and Hanscom AFB, MA. The latitude and longitude of each site is given in the table below.

SITE DESCRIPTION

SHETLAND ISLAND, UK	Latitude 60.16 Longitude -1.15
THULE AB, GREENLAND	Latitude 76.55 Longitude -68.67
HANSCOM AFB, MA	Latitude 42.30 Longitude -71.16

The STEL-5010 single channel GPS data from all three sites are recorded at 20 Hz on ten inch magnetic tape in binary format. These data are currently being backed up on eight mm tapes. The processed data are ASCII files stored on computer hard disk. Strip charts displaying the L1 and L2 intensities, and DGD and DCP data as they were recorded are also available.

The STEL-5010 raw data can be processed in two ways. The data can be processed into an ASCII file in a tabular format containing one-minute averaged values at 20 second intervals of intensity scintillation (S4) for L1 and L2, slant TEC from DCP, rms DCP, azimuth, elevation, and geomagnetic latitude, longitude, time, and penetration angle at the IPP. The data can also be reduced into four individual ASCII files containing DGD and DCP, both as six second averages, and intensity scintillation (S4) from L1 and L2, these being one-minute averaged values at 20-second intervals. Software was developed to plot these individual files for analysis, display, and quality checking purposes.

TI-4100 data were recorded in binary format on 40-megabyte DC2000 mini-data cartridges. The processed data files are stored as ASCII files on hard disks.

The Transit data were collected on Verbatim DC30 data cassettes in binary format. Processed data files are in ASCII on hard disk.

The data collected by the AIR GPS receiver are stored in the receiver's RAM and archived once a week to files on hard disk.

Each of the following 25 pages shows one month broken down into days. Specified by site, the listing includes a column for each receiver type. An X indicates that raw data from that site, on that day, collected by that receiver, are available. An O appears if no data exist. In a separate column, Y for yes and N for no indicates if the data have been processed. The last column shows the quality of the data that have been processed; 0 if data not processed, 1 for good, 2 for questionable possibly recoverable, and 3 for bad.

Note that UCW Transit data from 1992 exist. When a detailed listing of that information is obtained, it will be included in the updated log

	Shetland GPS STI 5010	Shetland GPS TI-4100	Shetland Transit UCW	PL	Hanscom GPS'S STI	NIMS	Hanscom Transit Magnavox	Thule GPS STI 5010	Data Processed From Sites 1 2 3 4 5 6 7 8	Quality Of Processed Data 1 = OK/2 = ?/3 = BAD
1-Dec-90	0	X	X	0	X	0	0	X	N Y Y N N N N Y	0 1 1 0 1 0 0 1
2-Dec-90	0	X	X	0	X	0	0	X	N Y Y N N N N Y	0 1 1 0 1 0 0 1
3-Dec-90	0	X	X	0	X	0	0	X	N Y Y N N N N Y	0 1 1 0 1 0 0 1
4-Dec-90	0	X	X	0	X	0	0	X	N Y Y N N N N Y	0 1 1 0 1 0 0 1
5-Dec-90	0	X	X	0	X	0	0	X	N Y Y N N N Y Y	0 1 1 0 1 0 0 1
6-Dec-90	0	X	X	0	X	0	0	X	N Y Y N N N Y Y	0 1 1 0 1 0 0 1
7-Dec-90	0	X	X	0	X	0	0	X	N Y Y N N N N Y	0 1 1 0 1 0 0 1
8-Dec-90	0	X	X	0	X	0	0	X	N Y Y N N N N Y	0 1 1 0 1 0 0 1
9-Dec-90	0	X	X	0	X	0	0	X	N Y Y N N N N Y	0 1 1 0 1 0 0 1
10-Dec-90	0	X	X	0	X	0	0	X	N Y Y N N N N Y	0 1 1 0 1 0 0 1
11-Dec-90	0	X	X	0	X	0	0	X	N Y Y N N N N Y	0 1 1 0 1 0 0 1
12-Dec-90	0	X	X	0	X	0	0	X	N Y Y N N N N Y	0 1 1 0 1 0 0 1
13-Dec-90	0	X	X	0	X	0	0	X	N Y Y N N N N Y	0 1 1 0 1 0 0 1
14-Dec-90	0	X	X	0	X	0	0	X	N Y Y N N N N Y	0 1 1 0 1 0 0 1
15-Dec-90	0	X	0	0	X	0	0	X	N Y Y N N N N Y	0 1 0 0 1 0 0 1
16-Dec-90	0	X	0	0	X	0	0	X	N Y Y N N N N Y	0 1 0 0 1 0 0 1
17-Dec-90	0	X	0	0	X	0	0	X	N Y Y N N N N Y	0 1 0 0 1 0 0 1
18-Dec-90	0	X	0	0	X	0	0	X	N Y Y N N N N Y	0 1 0 0 1 0 0 1
19-Dec-90	0	X	0	0	X	0	0	X	N Y Y N N N N Y	0 1 0 0 1 0 0 1
20-Dec-90	0	X	0	0	X	0	0	X	N Y Y N N N N Y	0 1 0 0 1 0 0 1
21-Dec-90	0	X	0	0	X	0	0	X	N Y Y N N N N Y	0 1 0 0 1 0 0 1
22-Dec-90	0	X	0	0	X	0	0	X	N Y Y N N N N Y	0 1 0 0 1 0 0 1
23-Dec-90	0	X	0	0	X	0	0	X	N Y Y N N N N Y	0 1 0 0 1 0 0 1
24-Dec-90	0	X	0	0	X	0	0	X	N Y Y N N N N Y	0 1 0 0 1 0 0 1
25-Dec-90	0	X	0	0	X	0	0	X	N Y Y N N N N Y	0 1 0 0 1 0 0 1
26-Dec-90	0	X	0	0	X	0	0	X	N Y Y N N N N Y	0 1 0 0 1 0 0 1
27-Dec-90	0	X	0	0	X	0	0	X	N Y Y N N N N Y	0 1 0 0 1 0 0 1
28-Dec-90	0	X	0	0	X	0	0	X	N Y Y N N N N Y	0 1 0 0 1 0 0 1
29-Dec-90	0	X	0	0	X	0	0	X	N Y Y N N N N Y	0 1 0 0 1 0 0 1
30-Dec-90	0	X	0	0	X	0	0	X	N Y Y N N N N Y	0 1 0 0 1 0 0 1
31-Dec-90	0	X	0	0	X	0	0	X	N Y Y N N N N Y	0 1 0 0 1 0 0 1

	Shetland	Shetland	Shetland		Hanscom		Hanscom	Thule	Data Processed	Quality Of
	GPS	GPS	Transit		GPS'S		Transit	GPS	From Sites	Processed Data
	STI 5010	TI-4100	UCW	PL	STI	NIMS	Magnavox	STI 5010	1 2 3 4 5 6 7 8	1 = OK/2 = ?/3 = BAD
1-Jan-91	O	X	X	O	X	O	O	X	N Y Y N N N N Y	0 1 1 0 0 0 0 1
2-Jan-91	O	X	X	O	X	O	O	X	N Y Y N N N N Y	0 1 1 0 0 0 0 1
3-Jan-91	O	X	X	O	X	O	O	X	N Y Y N N N N Y	0 1 1 0 0 0 0 1
4-Jan-91	O	X	X	O	X	O	O	X	N Y Y N N N N Y	0 1 1 0 0 0 0 1
5-Jan-91	O	X	X	O	X	O	X	X	N Y Y N N N Y Y	0 1 1 0 0 0 1 1
6-Jan-91	O	X	X	O	X	O	X	X	N Y Y N N N Y Y	0 1 1 0 0 0 1 1
7-Jan-91	O	X	X	O	X	O	O	X	N Y Y N N N N Y	0 1 1 0 0 0 0 1
8-Jan-91	O	X	X	O	X	O	O	X	N Y Y N N N N Y	0 1 1 0 0 0 0 1
9-Jan-91	O	X	X	O	X	O	O	X	N Y Y N N N N Y	0 1 1 0 0 0 0 1
10-Jan-91	O	X	X	O	X	O	O	X	N Y Y N N N N Y	0 1 1 0 0 0 0 1
11-Jan-91	O	X	X	O	X	O	O	O	N Y Y N N N N N	0 1 1 0 0 0 0 0
12-Jan-91	O	X	X	O	X	O	O	O	N Y Y N N N N N	0 1 1 0 0 0 0 0
13-Jan-91	O	X	X	O	X	O	O	O	N Y Y N N N N N	0 1 1 0 0 0 0 0
14-Jan-91	O	X	X	O	X	O	O	O	N Y Y N N N N N	0 1 1 0 0 0 0 0
15-Jan-91	O	X	O	O	X	O	O	O	N Y N N N N N N	0 1 0 0 0 0 0 0
16-Jan-91	O	X	O	O	X	O	O	O	N Y N N N N N N	0 1 0 0 0 0 0 0
17-Jan-91	O	X	O	O	X	O	O	O	N Y N N N N N N	0 1 0 0 0 0 0 0
18-Jan-91	O	X	O	O	X	O	O	O	N Y N N N N N N	0 1 0 0 0 0 0 0
19-Jan-91	O	X	O	O	X	O	O	O	N Y N N N N N N	0 1 0 0 0 0 0 0
20-Jan-91	O	X	O	O	X	O	O	O	N Y N N N N N N	0 1 0 0 0 0 0 0
21-Jan-91	O	X	O	O	X	O	O	O	N Y N N N N N N	0 1 0 0 0 0 0 0
22-Jan-91	O	X	O	O	X	O	O	O	N Y N N N N N N	0 1 0 0 0 0 0 0
23-Jan-91	O	X	O	O	X	O	O	O	N Y N N N N N N	0 1 0 0 0 0 0 0
24-Jan-91	O	X	O	O	X	O	O	O	N Y N N N N N N	0 1 0 0 0 0 0 0
25-Jan-91	O	X	O	O	X	O	O	O	N Y N N N N N N	0 1 0 0 0 0 0 0
26-Jan-91	O	X	O	O	X	O	O	O	N Y N N N N N N	0 1 0 0 0 0 0 0
27-Jan-91	O	X	O	O	X	O	O	O	N Y N N N N N N	0 1 0 0 0 0 0 0
28-Jan-91	O	X	O	O	X	O	O	O	N Y N N N N N N	0 1 0 0 0 0 0 0
29-Jan-91	O	X	O	O	X	O	O	O	N Y N N N N N N	0 1 0 0 0 0 0 0
30-Jan-91	O	X	O	O	X	O	O	O	N Y N N N N N N	0 1 0 0 0 0 0 0
31-Jan-91	O	X	O	O	X	O	O	O	N Y N N N N N N	0 1 0 0 0 0 0 0

	Shetland GPS STI 5010	Shetland GPS TI-4100	Shetland Transit UCW	PL	Hanscom GPS'S STI	NIMS	Hanscom Transit Magnavox	Thule GPS STI 5010	Data Processed From Sites 1 2 3 4 5 6 7 8	Quality Of Processed Data 1 = OK/2 = ?/3 = BAD
1-Feb-91	O	X	X	O	X	O	O	O	N Y Y N N N N N	0 ? 1 0 0 0 0 0
2-Feb-91	O	X	X	O	X	O	O	O	N Y Y N N N N N	0 ? 1 0 0 0 0 0
3-Feb-91	O	X	X	O	X	O	O	O	N Y Y N N N N N	0 1 1 0 0 0 0 0
4-Feb-91	O	X	X	O	X	O	O	O	N Y Y N N N N N	0 1 1 0 0 0 0 0
5-Feb-91	O	X	X	O	X	O	O	O	N Y Y N N N N N	0 1 1 0 0 0 0 0
6-Feb-91	O	X	X	O	X	O	O	O	N Y Y N N N N N	0 1 1 0 0 0 0 0
7-Feb-91	O	X	X	O	X	O	O	O	N Y Y N N N N N	0 1 1 0 0 0 0 0
8-Feb-91	O	X	X	O	X	O	O	O	N Y Y N N N N N	0 1 1 0 0 0 0 0
9-Feb-91	O	X	X	O	X	O	O	O	N Y Y N N N N N	0 1 1 0 0 0 0 0
10-Feb-91	O	X	X	O	X	O	O	O	N Y Y N N N N N	0 1 1 0 0 0 0 0
11-Feb-91	O	X	X	O	X	O	O	O	N Y Y N N N N N	0 1 1 0 0 0 0 0
12-Feb-91	O	X	X	O	X	O	O	O	N Y Y N N N N N	0 1 1 0 0 0 0 0
13-Feb-91	O	X	X	O	X	O	O	O	N Y Y N N N N N	0 1 1 0 0 0 0 0
14-Feb-91	O	X	X	O	X	O	O	O	N Y Y N N N N N	0 1 1 0 0 0 0 0
15-Feb-91	O	X	X	O	X	O	O	O	N Y Y N N N N N	0 1 1 0 0 0 0 0
16-Feb-91	O	X	X	O	X	O	O	O	N Y Y N N N N N	0 1 1 0 0 0 0 0
17-Feb-91	O	X	X	O	X	O	O	O	N Y Y N N N N N	0 1 1 0 0 0 0 0
18-Feb-91	O	X	X	O	X	O	O	O	N Y Y N N N N N	0 1 1 0 0 0 0 0
19-Feb-91	O	X	X	O	X	O	O	O	N Y Y N N N N N	0 1 1 0 0 0 0 0
20-Feb-91	O	X	X	O	X	O	O	O	N Y Y N N N N N	0 1 1 0 0 0 0 0
21-Feb-91	O	X	X	O	X	O	O	X	N Y Y N N N N Y	0 1 1 0 0 0 0 1
22-Feb-91	O	X	X	O	X	O	O	X	N Y Y N N N N Y	0 1 1 0 0 0 0 1
23-Feb-91	O	X	X	O	X	O	O	X	N Y Y N N N N Y	0 1 1 0 0 0 0 1
24-Feb-91	O	X	X	O	X	O	O	X	N Y Y N N N N Y	0 1 1 0 0 0 0 1
25-Feb-91	O	X	X	O	X	O	O	X	N Y Y N N N N Y	0 1 1 0 0 0 0 1
26-Feb-91	O	X	X	O	X	O	O	X	N Y Y N N N N Y	0 1 1 0 0 0 0 1
27-Feb-91	X	X	X	O	X	O	O	X	Y Y Y N N N N Y	1 1 1 0 0 0 0 1
28-Feb-91	X	X	X	O	X	O	O	X	Y Y Y N N N N Y	1 1 1 0 0 0 0 1

	Shetland	Shetland	Shetland		Hanscom		Hanscom	Thule	Data Processed	Quality Of
	GPS	GPS	Transit		GPS'S		Transit	GPS	From Sites	Processed Data
	STI 5010	TI-4100	UCW	PL	STI	NIMS	Magnavox	STI 5010	1 2 3 4 5 6 7 8	1 = OK/2 = ?/3 = BAD
1-Mar-91	X	X	X	0	X	0	0	X	Y Y Y N N N N Y	1 1 1 0 0 0 0 1
2-Mar-91	X	X	X	0	X	0	0	X	Y Y Y N N N N Y	1 1 1 0 0 0 0 1
3-Mar-91	X	X	X	0	X	0	0	X	Y Y Y N N N N Y	1 1 1 0 0 0 0 1
4-Mar-91	X	X	X	0	X	0	0	X	Y Y Y N N N N Y	1 1 1 0 0 0 0 1
5-Mar-91	X	X	X	0	X	0	0	0	Y Y Y N N N N N	1 1 1 0 0 0 0 0
6-Mar-91	X	X	X	0	X	0	0	0	Y Y Y N N N N N	1 1 1 0 0 0 0 0
7-Mar-91	X	X	X	0	X	0	0	X	Y Y Y N N N N Y	1 1 1 0 0 0 0 1
8-Mar-91	X	0	X	0	X	0	0	X	Y N Y N N N N Y	1 0 1 0 0 0 0 1
9-Mar-91	X	X	X	0	X	0	0	X	Y Y Y N N N N Y	1 1 1 0 0 0 0 1
10-Mar-91	X	X	X	0	X	0	0	X	Y Y Y N N N N Y	1 1 1 0 0 0 0 1
11-Mar-91	X	X	X	0	X	0	0	X	Y Y Y N N N N Y	1 1 1 0 0 0 0 1
12-Mar-91	X	X	X	0	X	0	0	X	Y Y Y N N N N Y	1 1 1 0 0 0 0 1
13-Mar-91	X	0	0	0	X	0	0	X	Y N N N N N N Y	1 0 0 0 0 0 0 1
14-Mar-91	X	X	X	0	X	0	0	X	Y Y Y N N N N Y	1 1 1 0 0 0 0 1
15-Mar-91	X	X	X	0	X	0	0	X	Y Y Y N N N N Y	1 1 1 0 0 0 0 1
16-Mar-91	X	X	X	0	X	0	0	X	Y Y Y N N N N Y	1 1 1 0 0 0 0 1
17-Mar-91	X	X	X	0	X	0	0	X	Y Y Y N N N N Y	1 1 1 0 0 0 0 1
18-Mar-91	X	X	X	0	X	0	0	X	Y Y Y N N N N Y	1 1 1 0 0 0 0 1
19-Mar-91	X	X	X	0	X	0	0	X	Y Y Y N N N N Y	1 1 1 0 0 0 0 1
20-Mar-91	X	X	X	0	X	0	0	X	Y Y Y N N N N Y	1 1 1 0 0 0 0 1
21-Mar-91	X	X	X	0	X	0	0	X	Y Y Y N N N N Y	1 1 1 0 0 0 0 1
22-Mar-91	X	X	0	0	X	0	0	X	Y Y N N N N N Y	1 1 0 0 0 0 0 1
23-Mar-91	X	X	X	0	X	0	0	X	Y Y Y N N N N Y	1 1 1 0 0 0 0 1
24-Mar-91	X	X	X	0	X	0	0	X	Y Y Y N N N N Y	1 1 1 0 0 0 0 1
25-Mar-91	X	X	X	0	X	0	0	X	Y Y Y N N N N Y	1 1 1 0 0 0 0 1
26-Mar-91	X	0	0	0	X	0	0	X	Y N N N N N N Y	1 0 0 0 0 0 0 1
27-Mar-91	X	X	X	0	X	0	0	X	Y Y Y N N N N Y	1 1 1 0 0 0 0 1
28-Mar-91	X	X	X	0	X	0	0	X	Y Y Y N N N N Y	1 1 1 0 0 0 0 1
29-Mar-91	0	0	X	0	X	0	0	X	N N Y N N N N Y	0 0 1 0 0 0 0 1
30-Mar-91	0	0	X	0	X	0	0	X	N N Y N N N N Y	0 0 1 0 0 0 0 1
31-Mar-91	0	0	X	0	X	0	0	X	N N Y N N N N Y	0 0 1 0 0 0 0 1

	Shetland	Shetland	Shetland		Hanscom		Hanscom	Thule	Data Processed	Quality Of
	GPS	GPS	Transit		GPS'S		Transit	GPS	From Sites	Processed Data
	STI 5010	TI-4100	UCW	PL	STI	NIMS	Magnavox	STI 5010	1 2 3 4 5 6 7 8	1 = OK/2 = ?/3 = BAD
1-Apr-91	O	O	X	O	X	O	O	X	N N Y N N N N Y	0 0 1 0 0 0 0 1
2-Apr-91	O	X	X	O	X	O	O	X	N Y Y N N N N Y	0 1 1 0 0 0 0 1
3-Apr-91	O	X	X	O	X	O	O	X	N Y Y N N N N Y	0 1 1 0 0 0 0 1
4-Apr-91	O	X	X	O	X	O	O	X	N Y Y N N N N Y	0 1 1 0 0 0 0 1
5-Apr-91	O	X	X	O	X	O	O	X	N Y Y N N N N Y	0 1 1 0 0 0 0 1
6-Apr-91	O	X	X	O	X	O	O	X	N Y Y N N N N Y	0 1 1 0 0 0 0 1
7-Apr-91	O	X	X	O	X	O	O	X	N Y Y N N N N Y	0 1 1 0 0 0 0 1
8-Apr-91	O	X	X	O	X	O	O	X	N Y Y N N N N Y	0 1 1 0 0 0 0 1
9-Apr-91	O	O	X	O	X	O	O	X	N N Y N N N N Y	0 0 1 0 0 0 0 1
10-Apr-91	O	X	X	O	X	O	O	X	N Y Y N N N N Y	0 1 1 0 0 0 0 1
11-Apr-91	O	X	X	O	X	O	O	X	N Y Y N N N N Y	0 1 1 0 0 0 0 1
12-Apr-91	O	X	X	O	X	O	O	X	N Y Y N N N N Y	0 1 1 0 0 0 0 1
13-Apr-91	O	X	O	O	X	O	O	X	N N Y N N N N Y	0 0 0 0 0 0 0 1
14-Apr-91	O	X	X	O	X	O	O	X	N Y Y N N N N Y	0 1 1 0 0 0 0 1
15-Apr-91	O	X	X	O	X	O	O	X	N Y Y N N N N Y	0 1 1 0 0 0 0 1
16-Apr-91	O	O	X	O	X	O	O	X	N N Y N N N N Y	0 0 1 0 0 0 0 1
17-Apr-91	O	O	X	O	X	O	O	X	N N Y N N N N Y	0 0 1 0 0 0 0 1
18-Apr-91	O	O	X	O	X	O	O	X	N N Y N N N N Y	0 0 1 0 0 0 0 1
19-Apr-91	O	O	X	O	X	O	O	X	N N Y N N N N Y	0 0 1 0 0 0 0 1
20-Apr-91	O	O	X	O	X	O	O	X	N N Y N N N N Y	0 0 1 0 0 0 0 1
21-Apr-91	O	O	X	O	X	O	O	X	N N Y N N N N Y	0 0 1 0 0 0 0 1
22-Apr-91	O	O	O	O	X	O	O	X	N N N N N N N Y	0 0 0 0 0 0 0 1
23-Apr-91	O	X	X	O	X	O	O	X	N Y Y N N N N Y	0 1 1 0 0 0 0 1
24-Apr-91	O	O	X	O	X	O	O	X	N N Y N N N N Y	0 0 1 0 0 0 0 1
25-Apr-91	O	O	X	O	X	O	O	X	N N Y N N N N Y	0 0 1 0 0 0 0 1
26-Apr-91	O	O	O	O	X	O	O	X	N N N N N N N Y	0 0 0 0 0 0 0 1
27-Apr-91	O	O	X	O	X	O	O	X	N N Y N N N N Y	0 0 1 0 0 0 0 1
28-Apr-91	O	O	X	O	X	O	O	X	N N Y N N N N Y	0 0 1 0 0 0 0 1
29-Apr-91	O	X	X	O	X	O	O	X	N Y Y N N N N Y	0 1 1 0 0 0 0 1
30-Apr-91	O	X	X	O	X	O	O	X	N Y Y N N N N Y	0 1 1 0 0 0 0 1

	Shetland GPS STI 5010	Shetland GPS TI-4100	Shetland Transit UCW	Shetland Transit PL	Hanscom GPS'S STI	Hanscom GPS'S NIMS	Hanscom Transit Magnavox	Thule GPS STI 5010	Data Processed From Sites 1	2	3	4	5	6	7	8	Quality Of Processed Data 1=OK/2=?/3=BAD
1-May-91	O	X	X	O	X	O	O	X	N	Y	Y	N	N	N	N	Y	0 1 1 0 0 0 0 1
2-May-91	O	X	X	O	X	O	O	X	N	Y	Y	N	N	N	N	Y	0 1 1 0 0 0 0 1
3-May-91	O	X	X	O	X	O	O	X	N	Y	Y	N	N	N	N	Y	0 1 1 0 0 0 0 1
4-May-91	O	O	X	O	X	O	O	X	N	N	Y	N	N	N	N	Y	0 0 1 0 0 0 0 1
5-May-91	O	X	X	O	X	O	O	X	N	Y	Y	N	N	N	N	Y	0 1 1 0 0 0 0 1
6-May-91	O	X	X	O	X	O	O	X	N	Y	Y	N	N	N	N	Y	0 1 1 0 0 0 0 1
7-May-91	O	X	X	O	X	O	O	X	N	Y	Y	N	N	N	N	Y	0 1 1 0 0 0 0 1
8-May-91	O	X	X	O	X	O	O	X	N	Y	Y	N	N	N	N	Y	0 1 1 0 0 0 0 1
9-May-91	O	X	X	O	X	O	O	X	N	N	Y	N	N	N	N	Y	0 1 1 0 0 0 0 1
10-May-91	O	O	X	O	X	O	O	O	N	N	Y	N	N	N	N	N	0 0 1 0 0 0 0 0
11-May-91	O	O	X	O	X	O	O	O	N	N	Y	N	N	N	N	N	0 0 1 0 0 0 0 0
12-May-91	O	O	X	O	X	O	O	X	N	N	Y	N	N	N	N	Y	0 1 1 0 0 0 0 1
13-May-91	O	O	O	O	X	O	O	X	N	N	N	N	N	N	N	Y	0 0 0 0 0 0 0 1
14-May-91	O	O	X	O	X	O	O	X	N	N	Y	N	N	N	N	Y	0 0 1 0 0 0 0 1
15-May-91	O	O	X	O	X	O	O	X	N	N	Y	N	N	N	N	Y	0 0 1 0 0 0 0 1
16-May-91	O	O	X	O	X	O	O	X	N	N	Y	N	N	N	N	Y	0 0 1 0 0 0 0 1
17-May-91	O	O	X	O	X	O	O	X	N	N	Y	N	N	N	N	Y	0 0 1 0 0 0 0 1
18-May-91	O	O	X	O	X	O	O	X	N	N	Y	N	N	N	N	Y	0 0 1 0 0 0 0 1
19-May-91	O	O	X	O	X	O	O	X	N	N	Y	N	N	N	N	Y	0 0 1 0 0 0 0 1
20-May-91	O	X	X	O	X	O	O	O	N	Y	Y	N	N	N	N	N	0 1 1 0 0 0 0 0
21-May-91	O	X	X	O	X	O	O	O	N	Y	Y	N	N	N	N	N	0 1 1 0 0 0 0 0
22-May-91	O	X	O	O	X	O	O	X	N	N	Y	N	N	N	N	Y	0 0 1 0 0 0 0 1
23-May-91	O	O	X	O	X	O	O	X	N	N	Y	N	N	N	N	Y	0 1 1 0 0 0 0 1
24-May-91	O	X	X	O	X	O	O	X	N	Y	Y	N	N	N	N	Y	0 1 1 0 0 0 0 1
25-May-91	O	X	X	O	X	O	O	X	N	Y	Y	N	N	N	N	Y	0 1 1 0 0 0 0 1
26-May-91	O	X	O	O	X	O	O	X	N	Y	N	N	N	N	N	Y	0 0 0 0 0 0 0 1
27-May-91	X	X	X	O	X	O	O	X	Y	Y	Y	N	N	N	N	Y	1 1 1 0 0 0 0 1
28-May-91	X	O	X	O	X	O	O	X	Y	N	Y	N	N	N	N	Y	1 1 1 0 0 0 0 1
29-May-91	X	O	X	O	X	O	O	X	Y	N	Y	N	N	N	N	Y	1 1 1 0 0 0 0 1
30-May-91	X	O	X	O	X	O	O	X	Y	N	Y	N	N	N	N	Y	1 1 1 0 0 0 0 1
31-May-91	X	O	X	O	X	O	O	X	Y	N	Y	N	N	N	N	Y	1 1 1 0 0 0 0 1

	Shetland GPS STI 5010	Shetland GPS TI-4100	Shetland Transit UCW	Shetland Transit PL	Hanscom GPS'S STI	Hanscom GPS'S NIMS	Hanscom Transit Magnavox	Thule GPS STI 5010	Data Processed From Sites 1 2 3 4 5 6 7 8	Quality Of Processed Data 1 = OK/2 = ?/3 = BAD
1-Jun-91	X	O	X	O	X	O	O	X	Y N Y N N N N Y	1 0 1 0 0 0 0 1
2-Jun-91	O	O	X	O	X	O	O	X	N N Y N N N N Y	0 1 1 0 0 0 0 1
3-Jun-91	O	O	X	O	X	O	O	X	N N Y N N N N Y	0 1 1 0 0 0 0 1
4-Jun-91	O	O	X	O	X	O	O	X	N N Y N N N N Y	0 0 1 0 0 0 0 1
5-Jun-91	X	O	X	O	X	O	O	X	Y N Y N N N N Y	1 0 1 0 0 0 0 1
6-Jun-91	X	X	X	O	X	O	O	X	Y Y Y N N N N Y	1 1 1 0 0 0 0 1
7-Jun-91	X	O	X	O	X	O	O	X	Y N Y N N N N Y	1 0 1 0 0 0 0 1
8-Jun-91	X	X	X	O	X	O	O	X	Y Y Y N N N N Y	1 1 1 0 0 0 0 1
9-Jun-91	X	X	X	O	X	O	O	X	Y Y Y N N N N Y	1 1 1 0 0 0 0 1
10-Jun-91	X	O	X	O	X	O	O	X	Y N Y N N N N Y	1 0 1 0 0 0 0 1
11-Jun-91	X	O	X	O	X	O	O	X	Y N Y N N N N Y	1 0 1 0 0 0 0 1
12-Jun-91	X	O	X	O	X	O	O	X	Y N Y N N N N Y	1 0 1 0 0 0 0 1
13-Jun-91	X	O	X	O	X	O	O	X	Y N Y N N N N Y	1 0 1 0 0 0 0 1
14-Jun-91	X	O	X	O	X	O	O	X	Y N Y N N N N Y	1 0 1 0 0 0 0 1
15-Jun-91	X	O	X	O	X	O	O	X	Y N Y N N N N Y	1 0 1 0 0 0 0 1
16-Jun-91	X	X	X	O	X	O	O	X	Y Y Y N N N N Y	1 1 1 0 0 0 0 1
17-Jun-91	X	X	X	O	X	O	O	X	Y Y Y N N N N Y	1 1 1 0 0 0 0 1
18-Jun-91	X	X	X	O	X	O	O	X	Y Y Y N N N N Y	1 1 1 0 0 0 0 1
19-Jun-91	X	X	X	O	X	O	O	X	Y Y Y N N N N Y	1 1 1 0 0 0 0 1
20-Jun-91	X	X	X	O	X	O	O	X	Y Y Y N N N N Y	1 1 1 0 0 0 0 1
21-Jun-91	X	X	X	O	X	O	O	X	Y Y Y N N N N Y	1 1 1 0 0 0 0 1
22-Jun-91	X	X	X	O	X	O	O	X	Y Y Y N N N N Y	1 1 1 0 0 0 0 1
23-Jun-91	X	X	X	O	X	O	O	X	Y Y Y N N N N Y	1 1 1 0 0 0 0 1
24-Jun-91	X	O	X	O	X	O	O	X	Y N Y N N N N Y	1 0 1 0 0 0 0 1
25-Jun-91	X	O	X	O	X	O	O	X	Y N Y N N N N Y	1 0 1 0 0 0 0 1
26-Jun-91	X	O	X	O	X	O	O	X	Y N Y N N N N Y	1 0 1 0 0 0 0 1
27-Jun-91	X	X	X	O	X	O	O	X	Y Y Y N N N N Y	1 1 1 0 0 0 0 1
28-Jun-91	X	X	X	O	X	O	O	X	Y Y Y N N N N Y	1 1 1 0 0 0 0 1
29-Jun-91	X	X	X	O	X	O	O	X	Y Y Y N N N N Y	1 1 1 0 0 0 0 1
30-Jun-91	X	X	X	O	X	O	O	X	Y Y Y N N N N Y	1 1 1 0 0 0 0 1

	Shetland	Shetland	Shetland		Hanscom		Hanscom	Thule	Data Processed	Quality Of
	GPS	GPS	Transit		GPS'S		Transit	GPS	From Sites	Processed Data
	STI 5010	TI-4100	UCW	PL	STI	NIMS	Magnavox	STI 5010	1 2 3 4 5 6 7 8	1 = OK/2 = ?/3 = BAD
1-Jul-91	X	X	X	0	X	0	0	X	Y Y Y N N N N Y	1 1 1 0 0 0 0 1
2-Jul-91	X	X	X	0	X	0	0	X	Y Y Y N N N N Y	1 1 1 0 0 0 0 1
3-Jul-91	X	X	X	0	X	0	0	X	Y Y Y N N N N Y	1 1 1 0 0 0 0 1
4-Jul-91	X	X	X	0	X	0	0	X	Y Y Y N N N N Y	1 1 1 0 0 0 0 1
5-Jul-91	X	X	X	0	X	0	0	X	Y Y Y N N N N Y	1 1 1 0 0 0 0 1
6-Jul-91	X	X	X	0	X	0	0	X	Y Y Y N N N N Y	1 1 1 0 0 0 0 1
7-Jul-91	X	X	X	0	X	0	0	X	Y Y Y N N N N Y	1 1 1 0 0 0 0 1
8-Jul-91	X	X	X	0	X	0	0	X	Y Y Y N N N N Y	1 1 1 0 0 0 0 1
9-Jul-91	X	X	X	0	X	0	0	X	Y Y Y N N N N Y	1 1 1 0 0 0 0 1
10-Jul-91	X	X	X	0	X	0	0	X	Y Y Y N N N N Y	1 1 1 0 0 0 0 1
11-Jul-91	X	X	X	0	X	0	0	X	Y Y Y N N N N Y	1 1 1 0 0 0 0 1
12-Jul-91	X	X	X	0	X	0	0	X	Y Y Y N N N N Y	1 1 1 0 0 0 0 1
13-Jul-91	X	X	X	0	X	0	0	X	Y Y Y N N N N Y	1 1 1 0 0 0 0 1
14-Jul-91	X	X	X	0	X	0	0	X	Y Y Y N N N N Y	1 1 1 0 0 0 0 1
15-Jul-91	X	0	X	0	X	0	0	X	Y N Y N N N N Y	1 0 1 0 0 0 0 1
16-Jul-91	X	0	X	0	X	0	0	X	Y N Y N N N N Y	1 0 1 0 0 0 0 1
17-Jul-91	X	0	X	0	X	0	0	X	Y N Y N N N N Y	1 0 1 0 0 0 0 1
18-Jul-91	X	X	X	0	X	0	0	X	Y Y Y N N N N Y	1 1 1 0 0 0 0 1
19-Jul-91	X	X	X	0	X	0	0	X	Y Y Y N N N N Y	1 1 1 0 0 0 0 1
20-Jul-91	X	X	X	0	X	0	0	X	Y Y Y N N N N Y	1 1 1 0 0 0 0 1
21-Jul-91	X	X	X	0	X	0	0	X	Y Y Y N N N N Y	1 1 1 0 0 0 0 1
22-Jul-91	X	X	X	0	X	0	0	X	Y Y Y N N N N Y	1 1 1 0 0 0 0 1
23-Jul-91	X	X	X	0	X	0	0	X	Y Y Y N N N N Y	1 1 1 0 0 0 0 1
24-Jul-91	X	X	X	0	X	0	X	X	Y Y Y N N N Y Y	1 1 1 0 0 0 1 1
25-Jul-91	X	X	X	0	X	0	X	X	Y Y Y N N N Y Y	1 1 1 0 0 0 1 1
26-Jul-91	X	X	X	0	X	0	X	X	Y Y Y N N N Y Y	1 1 1 0 0 0 1 1
27-Jul-91	X	X	X	0	X	0	X	X	Y Y Y N N N Y Y	1 1 1 0 0 0 1 1
28-Jul-91	X	X	X	0	X	0	X	X	Y Y Y N N N Y Y	1 1 1 0 0 0 1 1
29-Jul-91	X	X	X	0	X	0	X	X	Y Y Y N N N Y Y	1 1 1 0 0 0 1 1
30-Jul-91	X	X	X	0	X	0	X	X	Y Y Y N N N Y Y	1 1 1 0 0 0 1 1
31-Jul-91	X	X	X	0	X	0	X	X	Y Y Y N N N Y Y	1 1 1 0 0 0 1 1

	Shetland	Shetland	Shetland		Hanscom		Hanscom	Thule	Data Processed	Quality Of
	GPS	GPS	Transit		GPS'S		Transit	GPS	From Sites	Processed Data
	STI 5010	TI-4100	UCW	PL	STI	NIMS	Magnavox	STI 5010	1 2 3 4 5 6 7 8	1 = OK/2 = ?/3 = BAD
1-Aug-91	X	X	X	0	X	0	X	X	Y Y Y N N N Y Y	1 1 1 0 0 0 1 1
2-Aug-91	X	X	X	0	X	0	X	X	Y Y Y N N N Y Y	1 1 1 0 0 0 1 1
3-Aug-91	X	X	X	0	X	0	X	X	Y Y Y N N N Y Y	1 1 1 0 0 0 1 1
4-Aug-91	X	X	X	0	X	0	X	X	Y Y Y N N N Y Y	1 1 1 0 0 0 1 1
5-Aug-91	X	X	X	0	X	0	X	X	Y Y Y N N N Y Y	1 1 1 0 0 0 1 1
6-Aug-91	X	0	X	0	X	0	X	X	Y N Y N N N Y Y	1 0 1 0 0 0 1 1
7-Aug-91	X	X	X	0	X	0	X	X	Y Y Y N N N Y Y	1 1 1 0 0 0 1 1
8-Aug-91	X	X	X	0	X	0	X	X	Y Y Y N N N Y Y	1 1 1 0 0 0 1 1
9-Aug-91	X	X	X	0	X	0	X	X	Y Y Y N N N Y Y	1 1 1 0 0 0 1 1
10-Aug-91	X	X	X	0	X	0	X	X	Y Y Y N N N Y Y	1 1 1 0 0 0 1 1
11-Aug-91	X	X	X	0	X	0	X	X	Y Y Y N N N Y Y	1 1 1 0 0 0 1 1
12-Aug-91	X	X	X	0	X	0	X	X	Y Y Y N N N Y Y	1 1 1 0 0 0 1 1
13-Aug-91	X	X	X	0	X	0	X	X	Y Y Y N N N Y Y	1 1 1 0 0 0 1 1
14-Aug-91	X	0	X	0	X	0	X	X	Y N Y N N N Y Y	1 0 1 0 0 0 1 1
15-Aug-91	X	X	X	0	X	0	X	X	Y Y Y N N N Y Y	1 1 1 0 0 0 1 1
16-Aug-91	X	X	X	0	X	0	X	X	Y Y Y N N N Y Y	1 1 1 0 0 0 1 1
17-Aug-91	X	X	X	0	X	0	X	X	Y Y Y N N N Y Y	1 1 1 0 0 0 1 1
18-Aug-91	X	X	X	0	X	0	X	X	Y Y Y N N N Y Y	1 1 1 0 0 0 1 1
19-Aug-91	X	X	X	0	X	0	X	X	Y Y Y N N N Y Y	1 1 1 0 0 0 1 1
20-Aug-91	X	X	X	0	X	0	X	X	Y Y Y N N N Y Y	1 1 1 0 0 0 1 1
21-Aug-91	X	X	X	0	X	0	X	X	Y Y Y N N N Y Y	1 1 1 0 0 0 1 1
22-Aug-91	X	X	X	0	X	0	X	X	Y Y Y N N N Y Y	1 1 1 0 0 0 1 1
23-Aug-91	X	X	X	0	X	0	X	X	Y Y Y N N N Y Y	1 1 1 0 0 0 1 1
24-Aug-91	X	X	X	0	X	0	X	X	Y Y Y N N N Y Y	1 1 1 0 0 0 1 1
25-Aug-91	X	X	X	0	X	0	X	X	Y Y Y N N N Y Y	1 1 1 0 0 0 1 1
26-Aug-91	X	0	X	0	X	0	0	X	Y N Y N N N N Y	1 0 1 0 0 0 0 1
27-Aug-91	X	0	X	0	X	0	0	X	Y N Y N N N N Y	1 0 1 0 0 0 0 1
28-Aug-91	X	0	X	0	X	0	0	X	Y N Y N N N N Y	1 0 1 0 0 0 0 1
29-Aug-91	X	0	X	0	X	0	0	X	Y N Y N N N N Y	1 0 1 0 0 0 0 1
30-Aug-91	X	0	X	0	X	0	0	X	Y N Y N N N N Y	1 0 1 0 0 0 0 1
31-Aug-91	X	0	X	0	X	0	0	X	Y N Y N N N N Y	1 0 1 0 0 0 0 1

	Shetland	Shetland	Shetland		Hanscom		Hanscom	Thule	Data Processed								Quality Of							
	GPS	GPS	Transit		GPS'S		Transit	GPS	From Sites								Processed Data							
	STI 5010	TI-4100	UCW	PL	STI	NIMS	Magnavox	STI 5010	1	2	3	4	5	6	7	8	1 = OK/2 = ?/3 = BAD							
1-Sep-91	X	O	X	O	X	O	O	X	Y	N	Y	N	N	N	N	Y	1	0	1	0	0	0	0	1
2-Sep-91	X	O	X	O	X	O	O	X	Y	N	Y	N	N	N	N	Y	1	0	1	0	0	0	0	1
3-Sep-91	X	O	X	O	X	O	O	X	Y	N	Y	N	N	N	N	Y	1	0	1	0	0	0	0	1
4-Sep-91	X	X	X	O	X	O	O	X	Y	Y	Y	N	N	N	N	Y	1	1	1	0	0	0	0	1
5-Sep-91	X	X	X	O	X	O	O	X	Y	Y	Y	N	N	N	N	Y	1	1	1	0	0	0	0	1
6-Sep-91	X	X	X	O	X	O	O	X	Y	Y	Y	N	N	N	N	Y	1	1	1	0	0	0	0	1
7-Sep-91	X	O	X	O	X	O	O	X	Y	N	Y	N	N	N	N	Y	1	0	1	0	0	0	0	1
8-Sep-91	X	X	X	O	X	O	O	X	Y	Y	Y	N	N	N	N	Y	1	1	1	0	0	0	0	1
9-Sep-91	X	X	X	O	X	O	O	X	Y	Y	Y	N	N	N	N	Y	1	1	1	0	0	0	0	1
10-Sep-91	X	X	X	O	X	O	O	X	Y	Y	Y	N	N	N	N	Y	1	1	1	0	0	0	0	1
11-Sep-91	X	X	X	O	X	O	O	X	Y	Y	Y	N	N	N	N	Y	1	1	1	0	0	0	0	1
12-Sep-91	X	X	X	O	X	O	O	X	Y	Y	Y	N	N	N	N	Y	1	1	1	0	0	0	0	1
13-Sep-91	X	X	X	O	X	O	O	X	Y	Y	Y	N	N	N	N	Y	1	1	1	0	0	0	0	1
14-Sep-91	X	X	X	O	X	O	O	X	Y	Y	Y	N	N	N	N	Y	1	1	1	0	0	0	0	1
15-Sep-91	X	X	X	O	X	O	O	X	Y	Y	Y	N	N	N	N	Y	1	1	1	0	0	0	0	1
16-Sep-91	X	X	X	O	X	O	O	X	Y	Y	Y	N	N	N	N	Y	1	1	1	0	0	0	0	1
17-Sep-91	X	X	X	O	X	O	O	X	Y	Y	Y	N	N	N	N	Y	1	1	1	0	0	0	0	1
18-Sep-91	X	X	X	O	X	O	O	X	Y	Y	Y	N	N	N	N	Y	1	1	1	0	0	0	0	1
19-Sep-91	X	X	X	O	X	O	O	X	Y	Y	Y	N	N	N	N	Y	1	1	1	0	0	0	0	1
20-Sep-91	X	X	X	O	X	O	O	X	Y	Y	Y	N	N	N	N	Y	1	1	1	0	0	0	0	1
21-Sep-91	X	X	X	O	X	O	O	X	Y	Y	Y	N	N	N	N	Y	1	1	1	0	0	0	0	1
22-Sep-91	X	X	X	O	X	O	O	X	Y	Y	Y	N	N	N	N	Y	1	1	1	0	0	0	0	1
23-Sep-91	X	X	X	O	X	O	O	X	Y	Y	Y	N	N	N	N	Y	1	1	1	0	0	0	0	1
24-Sep-91	X	X	X	O	X	O	O	X	Y	Y	Y	N	N	N	N	Y	1	1	1	0	0	0	0	1
25-Sep-91	X	X	X	O	X	O	O	X	Y	Y	Y	N	N	N	N	Y	1	1	1	0	0	0	0	1
26-Sep-91	X	X	X	O	X	O	O	X	Y	Y	Y	N	N	N	N	Y	1	1	1	0	0	0	0	1
27-Sep-91	X	X	X	O	X	O	O	X	Y	Y	Y	N	N	N	N	Y	1	1	1	0	0	0	0	1
28-Sep-91	X	X	X	O	X	O	O	X	Y	Y	Y	N	N	N	N	Y	1	1	1	0	0	0	0	1
29-Sep-91	X	X	X	O	X	O	O	X	Y	Y	Y	N	N	N	N	Y	1	1	1	0	0	0	0	1
30-Sep-91	X	X	X	O	X	O	O	X	Y	Y	Y	N	N	N	N	Y	1	1	1	0	0	0	0	1

	Shetland GPS STI 5010	Shetland GPS TI-4100	Shetland Transit UCW	PL	Hanscom GPS'S STI	NIMS	Hanscom Transit Magnavox	Thule GPS STI 5010	Data Processed From Sites 1 2 3 4 5 6 7 8	Quality Of Processed Data 1=OK/2=?/3=BAD
1-Oct-91	X	X	X	0	X	0	0	X	Y Y Y N N N N Y	1 1 1 0 0 0 0 1
2-Oct-91	X	X	X	0	X	0	0	X	Y Y Y N N N N Y	1 1 1 0 0 0 0 1
3-Oct-91	X	X	X	0	X	0	0	X	Y Y Y N N N N Y	1 1 1 0 0 0 0 1
4-Oct-91	X	X	X	0	X	0	0	X	Y Y Y N N N N Y	1 1 1 0 0 0 0 1
5-Oct-91	X	X	X	0	X	0	0	X	Y Y Y N N N N Y	1 1 1 0 0 0 0 1
6-Oct-91	X	X	X	0	X	0	0	X	Y Y Y N N N N Y	1 1 1 0 0 0 0 1
7-Oct-91	X	X	X	0	X	0	0	X	Y Y Y N N N N Y	1 1 1 0 0 0 0 1
8-Oct-91	X	X	X	0	X	0	0	X	Y Y Y N N N N Y	1 1 1 0 0 0 0 1
9-Oct-91	X	0	X	0	X	0	0	X	Y N Y N N N N Y	1 0 1 0 0 0 0 1
10-Oct-91	X	X	X	0	X	0	0	X	Y Y Y N N N N Y	1 1 1 0 0 0 0 1
11-Oct-91	X	X	X	0	X	0	0	X	Y Y Y N N N N Y	1 1 1 0 0 0 0 1
12-Oct-91	X	X	X	0	X	0	0	X	Y Y Y N N N N Y	1 1 1 0 0 0 0 1
13-Oct-91	X	X	X	0	X	0	0	X	Y Y Y N N N N Y	1 1 1 0 0 0 0 1
14-Oct-91	X	X	X	0	X	0	0	X	Y Y Y N N N N Y	1 1 1 0 0 0 0 1
15-Oct-91	X	X	X	0	X	0	0	X	Y Y Y N N N N Y	1 1 1 0 0 0 0 1
16-Oct-91	X	X	X	0	X	0	0	X	Y Y Y N N N N Y	1 1 1 0 0 0 0 1
17-Oct-91	X	X	X	0	X	0	0	X	Y Y Y N N N N Y	1 1 1 0 0 0 0 1
18-Oct-91	X	X	X	0	X	0	0	X	Y Y Y N N N N Y	1 1 1 0 0 0 0 1
19-Oct-91	X	X	X	0	X	0	0	X	Y Y Y N N N N Y	1 1 1 0 0 0 0 1
20-Oct-91	X	0	X	0	X	0	0	X	Y N Y N N N N Y	1 0 1 0 0 0 0 1
21-Oct-91	X	X	X	0	X	0	0	X	Y Y Y N N N N Y	1 1 1 0 0 0 0 1
22-Oct-91	X	X	X	0	X	0	0	X	Y Y Y N N N N Y	1 1 1 0 0 0 0 1
23-Oct-91	X	0	X	0	X	0	0	X	Y N Y N N N N Y	1 0 1 0 0 0 0 1
24-Oct-91	X	0	X	0	X	0	0	X	Y N Y N N N N Y	1 0 1 0 0 0 0 1
25-Oct-91	X	0	X	0	X	0	X	X	Y N Y N N N Y Y	1 0 1 0 0 0 1 1
26-Oct-91	X	0	X	0	X	0	X	X	Y N Y N N N Y Y	1 0 1 0 0 0 1 1
27-Oct-91	X	X	X	0	X	0	X	X	Y N Y N N N Y Y	1 0 1 0 0 0 1 1
28-Oct-91	X	X	X	0	X	0	0	X	Y Y Y N N N N Y	1 1 1 0 0 0 0 1
29-Oct-91	X	X	X	0	X	0	0	X	Y Y Y N N N N Y	1 1 1 0 0 0 0 1
30-Oct-91	X	X	X	0	X	0	0	X	Y Y Y N N N N Y	1 1 1 0 0 0 0 1
31-Oct-91	X	X	X	0	X	0	0	X	Y Y Y N N N N Y	1 1 1 0 0 0 0 1

	Shetland	Shetland	Shetland		Hanscom		Hanscom	Thule	Data Processed	Quality Of
	GPS	GPS	Transit		GPS		Transit	GPS	From Sites	Processed Data
	STI 5010	TI-4100	UCW	PL	STI	NIMS	Magnavox	STI 5010	1 2 3 4 5 6 7 8	1 = OK/2 = ?/3 = BAD
1-Nov-91	O	X	X	O	O	O	O	X	N Y Y N N N N Y	0 1 1 0 0 0 0 1
2-Nov-91	O	X	X	O	O	O	O	X	N Y Y N N N N Y	0 1 1 0 0 0 0 1
3-Nov-91	O	X	X	O	O	O	O	X	N Y Y N N N N Y	0 1 1 0 0 0 0 1
4-Nov-91	O	O	X	O	O	O	O	X	N N Y N N N N Y	0 0 1 0 0 0 0 1
5-Nov-91	O	O	X	O	O	O	O	X	N N Y N N N N Y	0 0 1 0 0 0 0 1
6-Nov-91	O	O	X	O	O	O	O	O	N N Y N N N N N	0 0 1 0 0 0 0 1
7-Nov-91	O	X	X	O	O	O	O	O	N Y Y N N N N Y	0 1 1 0 0 0 0 1
8-Nov-91	O	X	X	O	O	O	O	O	N Y Y N N N N Y	0 1 1 0 0 0 0 1
9-Nov-91	O	X	X	O	O	O	O	O	N Y Y N N N N N	0 1 1 0 0 0 0 1
10-Nov-91	O	O	X	O	O	O	O	O	N N Y N N N N N	0 0 1 0 0 0 0 0
11-Nov-91	O	X	X	O	O	O	O	O	N Y Y N N N N N	0 1 1 0 0 0 0 0
12-Nov-91	O	X	X	O	O	O	O	O	N Y Y N N N N N	0 1 1 0 0 0 0 0
13-Nov-91	O	X	X	O	O	O	O	O	N Y Y N N N N N	0 1 1 0 0 0 0 0
14-Nov-91	O	X	X	O	O	O	O	O	N Y Y N N N N N	0 1 1 0 0 0 0 0
15-Nov-91	X	X	X	O	O	O	O	O	Y Y Y N N N N N	1 1 1 0 0 0 0 0
16-Nov-91	X	X	X	O	O	O	O	O	Y Y Y N N N N N	1 1 1 0 0 0 0 0
17-Nov-91	X	X	X	O	O	O	O	O	Y Y Y N N N N N	1 1 1 0 0 0 0 0
18-Nov-91	X	X	X	O	O	O	O	O	Y Y Y N N N N N	1 1 1 0 0 0 0 0
19-Nov-91	X	X	X	O	O	O	O	O	Y Y Y N N N N N	1 1 1 0 0 0 0 0
20-Nov-91	X	O	X	O	O	O	O	O	Y N Y N N N N N	1 0 1 0 0 0 0 0
21-Nov-91	X	X	X	O	O	O	O	O	Y Y Y N N N N N	1 1 1 0 0 0 0 0
22-Nov-91	X	O	X	O	O	O	O	O	Y N Y N N N N N	1 0 1 0 0 0 0 0
23-Nov-91	X	O	X	O	O	O	O	O	Y N Y N N N N N	1 0 1 0 0 0 0 0
24-Nov-91	X	O	X	O	O	O	O	O	Y N Y N N N N N	1 0 1 0 0 0 0 0
25-Nov-91	X	O	X	O	O	O	O	O	Y N Y N N N N N	1 0 1 0 0 0 0 0
26-Nov-91	X	O	X	O	O	O	O	X	Y N Y N N N N Y	1 0 1 0 0 0 0 1
27-Nov-91	X	O	X	X	O	O	O	X	Y N Y Y N N N Y	1 0 1 1 0 0 0 1
28-Nov-91	X	O	X	X	O	O	O	X	Y N Y Y N N N Y	1 0 1 1 0 0 0 1
29-Nov-91	X	O	X	X	O	O	O	X	Y N Y Y N N N Y	1 0 1 1 0 0 0 1
30-Nov-91	X	O	X	X	O	O	O	X	Y N Y Y N N N Y	1 0 1 1 0 0 0 1

	Shetland	Shetland	Shetland		Hanscom	Hanscom	Thule	Data Processed	Quality Of
	GPS	GPS	Transit		GPS'S	Transit	GPS	From Sites	Processed Data
	STI 5010	TI-4100	UCW	PL	STI NIMS	Magnavox	STI 5010	1 2 3 4 5 6 7 8	1 = OK/2 = ?/3 = BAD
1-Dec-91	X	O	X	O	O	O	X	Y N Y N N N N Y	1 0 1 0 0 0 0 1
2-Dec-91	X	X	X	O	O	O	X	Y Y Y N N N N Y	1 1 1 0 0 0 0 1
3-Dec-91	X	X	X	O	O	O	X	Y Y Y N N N N Y	1 1 1 0 0 0 0 1
4-Dec-91	X	X	X	O	O	O	X	Y Y Y N N N N Y	1 1 1 0 0 0 0 1
5-Dec-91	X	X	X	O	O	O	X	Y Y Y N N N N Y	1 1 1 0 0 0 0 1
6-Dec-91	X	X	X	O	O	O	X	Y Y Y N N N N Y	1 1 1 0 0 0 0 1
7-Dec-91	X	X	X	O	O	O	X	Y Y Y N N N N Y	1 1 1 0 0 0 0 1
8-Dec-91	X	X	X	O	O	O	X	Y Y Y N N N N Y	1 1 1 0 0 0 0 1
9-Dec-91	X	X	X	O	O	O	X	Y Y Y N N N N Y	1 1 1 0 0 0 0 1
10-Dec-91	X	X	X	O	O	O	O	Y Y Y N N N N N	1 1 1 0 0 0 0 0
11-Dec-91	X	X	X	X	O	X	O	Y Y Y Y N N Y N	1 1 1 1 0 0 1 0
12-Dec-91	X	X	X	X	O	X	X	Y Y Y Y N N Y Y	1 1 1 1 0 0 1 1
13-Dec-91	X	X	X	X	O	X	X	Y Y Y Y N N Y Y	1 1 1 1 0 0 1 1
14-Dec-91	X	X	X	X	O	X	X	Y Y Y Y N N Y Y	1 1 1 1 0 0 1 1
15-Dec-91	X	X	X	X	O	X	X	Y Y Y Y N N Y Y	1 1 1 1 0 0 1 1
16-Dec-91	X	X	X	X	O	X	X	Y Y Y Y N N Y Y	1 1 1 1 0 0 1 1
17-Dec-91	X	X	X	X	O	X	X	Y Y Y Y N N Y Y	1 1 1 1 0 0 1 1
18-Dec-91	X	X	X	X	O	X	X	Y Y Y Y N N Y Y	1 1 1 1 0 0 1 1
19-Dec-91	X	X	X	X	O	X	X	Y Y Y Y N N Y Y	1 1 1 1 0 0 1 1
20-Dec-91	X	X	X	X	O	X	O	Y Y Y Y N N Y N	1 1 1 1 0 0 1 0
21-Dec-91	X	X	X	X	O	X	O	Y Y Y Y N N Y N	1 1 1 1 0 0 1 0
22-Dec-91	X	X	X	X	O	X	X	Y Y Y Y N N Y Y	1 1 1 1 0 0 1 1
23-Dec-91	X	X	X	X	O	X	X	Y Y Y Y N N Y Y	1 1 1 1 0 0 1 1
24-Dec-91	X	X	X	X	O	X	X	Y Y Y Y N N Y Y	1 1 1 1 0 0 1 1
25-Dec-91	X	X	X	O	O	O	X	Y Y Y N N N N Y	1 1 1 0 0 0 0 1
26-Dec-91	X	X	X	O	O	O	X	Y Y Y N N N N Y	1 1 1 0 0 0 0 1
27-Dec-91	X	X	X	O	O	O	X	Y Y Y N N N N Y	1 1 1 0 0 0 0 1
28-Dec-91	X	X	X	O	O	O	X	Y Y Y N N N N Y	1 1 1 0 0 0 0 1
29-Dec-91	X	X	X	O	O	O	X	Y Y Y N N N N Y	1 1 1 0 0 0 0 1
30-Dec-91	X	X	X	O	O	O	X	Y Y Y N N N N Y	1 1 1 0 0 0 0 1
31-Dec-91	X	X	X	O	O	O	X	Y Y Y N N N N Y	1 1 1 0 0 0 0 1

	Shetland GPS STI 5010	Shetland GPS TI-4100	Shetland Transit UCW PL	Hanscom GPS'S STI NIMS	Hanscom Transit Magnavox	Thule GPS STI 5010	Data Processed From Sites 1 2 3 4 5 6 7 8	Quality Of Processed Data 1=OK/2=?/3=BAD
1-Jan-92	X	O	X	O	X	O	Y N Y Y N N Y N	1 0 1 1 0 0 1 0
2-Jan-92	X	O	X	O	X	O	Y N Y Y N N Y N	1 0 1 1 0 0 1 0
3-Jan-92	X	O	X	O	X	O	Y N Y Y N N Y N	1 0 1 1 0 0 1 0
4-Jan-92	X	X	X	O	X	O	Y Y Y Y N N Y N	1 1 1 1 0 0 1 0
5-Jan-92	X	X	X	O	X	O	Y Y Y Y N N Y N	1 1 1 1 0 0 1 0
6-Jan-92	X	X	X	O	X	O	Y Y Y Y N N Y N	1 1 1 1 0 0 1 0
7-Jan-92	X	X	X	O	X	X	Y Y Y Y N N Y Y	1 1 1 1 0 0 1 1
8-Jan-92	X	X	X	O	X	X	Y Y Y Y N N Y Y	1 1 1 1 0 0 1 1
9-Jan-92	X	X	X	O	X	X	Y Y Y Y N N Y Y	1 1 1 1 0 0 1 1
10-Jan-92	X	X	X	O	X	X	Y Y Y Y N N Y Y	1 1 1 1 0 0 1 1
11-Jan-92	X	X	X	O	X	X	Y Y Y Y N N Y Y	1 1 1 1 0 0 1 1
12-Jan-92	X	X	X	O	X	X	Y Y Y Y N N Y Y	1 1 1 1 0 0 1 1
13-Jan-92	X	X	X	O	X	X	Y Y Y Y N N Y Y	1 1 1 1 0 0 1 1
14-Jan-92	X	X	X	O	X	X	Y Y Y Y N N Y Y	1 1 1 1 0 0 1 1
15-Jan-92	X	X	X	O	X	X	Y Y Y Y N N Y Y	1 1 1 1 0 0 1 1
16-Jan-92	X	X	X	O	X	X	Y Y Y Y N N Y Y	1 1 1 1 0 0 1 1
17-Jan-92	X	X	X	O	X	X	Y Y Y Y N N Y Y	1 1 1 1 0 0 1 1
18-Jan-92	X	X	X	O	X	X	Y Y Y Y N N Y Y	1 1 1 1 0 0 1 1
19-Jan-92	X	X	X	O	X	X	Y Y Y Y N N Y Y	1 1 1 1 0 0 1 1
20-Jan-92	X	X	X	O	X	X	Y Y Y Y N N Y Y	1 1 1 1 0 0 1 1
21-Jan-92	X	X	X	O	X	X	Y Y Y Y N N Y Y	1 1 1 1 0 0 1 1
22-Jan-92	X	X	X	O	X	X	Y Y Y Y N N Y Y	1 1 1 1 0 0 1 1
23-Jan-92	X	X	X	O	X	X	Y Y Y Y N N Y Y	1 1 1 1 0 0 1 1
24-Jan-92	X	X	X	O	X	X	Y Y Y Y N N Y Y	1 1 1 1 0 0 1 1
25-Jan-92	X	X	X	O	X	X	Y Y Y Y N N Y Y	1 1 1 1 0 0 1 1
26-Jan-92	X	X	X	O	X	X	Y Y Y Y N N Y Y	1 1 1 1 0 0 1 1
27-Jan-92	X	X	X	O	X	X	Y Y Y Y N N Y Y	1 1 1 1 0 0 1 1
28-Jan-92	X	X	X	O	X	X	Y Y Y Y N N Y Y	1 1 1 1 0 0 1 1
29-Jan-92	X	X	X	O	X	X	Y Y Y Y N N Y Y	1 1 1 1 0 0 1 1
30-Jan-92	X	X	X	O	X	X	Y Y Y Y N N Y Y	1 1 1 1 0 0 1 1
31-Jan-92	X	X	X	O	X	X	Y Y Y Y N N Y Y	1 1 1 1 0 0 1 1

	Shetland GPS STI 5010	Shetland GPS TI-4100	Shetland Transit UCW PL	Hanscom GPS'S STI NIMS	Hanscom Transit Magnavox	Thule GPS STI 5010	Data Processed From Sites 1 2 3 4 5 6 7 8	Quality Of Processed Data 1 = OK/2 = ?/3 = BAD
1-Feb-92	X	X	X X	O	X	X	Y Y Y Y N N Y Y	1 1 1 1 0 0 1 1
2-Feb-92	X	X	X X	O	X	X	Y Y Y Y N N Y Y	1 1 1 1 0 0 1 1
3-Feb-92	X	X	X X	O	X	X	Y Y Y Y N N Y Y	1 1 1 1 0 0 1 1
4-Feb-92	X	X	X X	O	X	X	Y Y Y Y N N Y Y	1 1 1 1 0 0 1 1
5-Feb-92	X	X	X X	O	X	X	Y Y Y Y N N Y Y	1 1 1 1 0 0 1 1
6-Feb-92	X	X	X X	O	X	X	Y Y Y Y N N Y Y	1 1 1 1 0 0 1 1
7-Feb-92	X	X	X X	O	X	X	Y Y Y Y N N Y Y	1 1 1 1 0 0 1 1
8-Feb-92	X	X	X X	O	X	X	Y Y Y Y N N Y Y	1 1 1 1 0 0 1 1
9-Feb-92	X	O	X X	O	X	X	Y N Y Y N N Y Y	1 0 1 1 0 0 1 1
10-Feb-92	X	O	X X	O	X	X	Y N Y Y N N Y Y	1 0 1 1 0 0 1 1
11-Feb-92	X	O	X X	O	X	X	Y N Y Y N N Y Y	1 0 1 1 0 0 1 1
12-Feb-92	X	O	X X	O	X	X	Y N Y Y N N Y Y	1 0 1 1 0 0 1 1
13-Feb-92	X	O	X X	O	X	X	Y N Y Y N N Y Y	1 0 1 1 0 0 1 1
14-Feb-92	X	O	X X	O	X	X	Y N Y Y N N Y Y	1 0 1 1 0 0 1 1
15-Feb-92	X	O	X X	O	X	X	Y N Y Y N N Y Y	1 0 1 1 0 0 1 1
16-Feb-92	X	O	X X	O	X	X	Y N Y Y N N Y Y	1 0 1 1 0 0 1 1
17-Feb-92	X	O	X X	O	X	X	Y N Y Y N N Y Y	1 0 1 1 0 0 1 1
18-Feb-92	X	O	X X	O	X	X	Y N Y Y N N Y Y	1 0 1 1 0 0 1 1
19-Feb-92	X	O	X X	O	X	X	Y N Y Y N N Y Y	1 0 1 1 0 0 1 1
20-Feb-92	X	O	X X	O	X	X	Y N Y Y N N Y Y	1 0 1 1 0 0 1 1
21-Feb-92	X	O	X X	O	X	X	Y N Y Y N N Y Y	1 0 1 1 0 0 1 1
22-Feb-92	X	O	X X	O	X	X	Y N Y Y N N Y Y	1 0 1 1 0 0 1 1
23-Feb-92	X	O	X X	O	X	X	Y N Y Y N N Y Y	1 0 1 1 0 0 1 1
24-Feb-92	X	O	X X	O	X	X	Y N Y Y N N Y Y	1 0 1 1 0 0 1 1
25-Feb-92	X	O	X X	O	X	X	Y N Y Y N N Y Y	1 0 1 1 0 0 1 1
26-Feb-92	X	O	X X	O	X	X	Y N Y Y N N Y Y	1 0 1 1 0 0 1 1
27-Feb-92	X	O	X X	O	X	X	Y N Y Y N N Y Y	1 0 1 1 0 0 1 1
28-Feb-92	X	O	X X	O	X	X	Y N Y Y N N Y Y	1 0 1 1 0 0 1 1
29-Feb-92	X	O	X X	O	X	X	Y N Y Y N N Y Y	1 0 1 1 0 0 1 1

	Shetland GPS STI 5010	Shetland GPS TI-4100	Shetland Transit UCW PL	Hanscom GPS'S STI NIMS	Hanscom Transit Magnavox	Thule GPS STI 5010	Data Processed From Sites 1 2 3 4 5 6 7 8	Quality Of Processed Data 1 = OK/2 = ?/3 = BAD
1-Mar-92	X	O	X	O	O	X	Y N Y Y N N N Y	1 0 1 1 0 0 0 1
2-Mar-92	X	O	X	O	O	X	Y N Y Y N N N Y	1 0 1 1 0 0 0 1
3-Mar-92	X	O	X	O	O	X	Y N Y Y N N N Y	1 0 1 1 0 0 0 1
4-Mar-92	X	O	X	O	O	X	Y N Y Y N N N Y	1 0 1 1 0 0 0 1
5-Mar-92	X	O	X	O	O	X	Y N Y Y N N N Y	1 0 1 1 0 0 0 1
6-Mar-92	X	O	X	O	O	X	Y N Y Y N N N Y	1 0 1 1 0 0 0 1
7-Mar-92	X	O	X	O	O	X	Y N Y Y N N N Y	1 0 1 1 0 0 0 1
8-Mar-92	X	O	X	O	O	X	Y N Y Y N N N Y	1 0 1 1 0 0 0 1
9-Mar-92	X	O	X	O	O	X	Y N Y Y N N N N	1 0 1 1 0 0 0 2
10-Mar-92	X	O	X	O	O	X	Y N Y Y N N N N	1 0 1 1 0 0 0 2
11-Mar-92	X	O	X	O	O	X	Y N Y Y N N N N	1 0 1 1 0 0 0 2
12-Mar-92	X	O	X	O	O	X	Y N Y Y N N N N	1 0 1 1 0 0 0 2
13-Mar-92	X	O	X	O	O	X	Y N Y Y N N N N	1 0 1 1 0 0 0 2
14-Mar-92	X	O	X	O	O	X	Y N Y Y N N N N	1 0 1 1 0 0 0 2
15-Mar-92	X	O	X	O	O	X	Y N Y Y N N N N	1 0 1 1 0 0 0 2
16-Mar-92	X	O	X	O	O	X	Y N Y Y N N N N	1 0 1 1 0 0 0 2
17-Mar-92	X	O	X	O	O	X	Y N Y Y N N N N	1 0 1 1 0 0 0 2
18-Mar-92	X	O	X	O	O	X	Y N Y Y N N N N	1 0 1 1 0 0 0 2
19-Mar-92	X	O	X	O	O	X	Y N Y Y N N N N	1 0 1 1 0 0 0 2
20-Mar-92	X	O	X	O	O	X	Y N Y Y N N N N	1 0 1 1 0 0 0 2
21-Mar-92	X	O	X	O	O	X	Y N Y Y N N N N	1 0 1 1 0 0 0 2
22-Mar-92	X	O	X	O	O	X	Y N Y Y N N N N	1 0 1 1 0 0 0 2
23-Mar-92	X	O	X	O	O	X	Y N Y Y N N N N	1 0 1 1 0 0 0 2
24-Mar-92	X	O	X	O	O	X	Y N Y Y N N N N	1 0 1 1 0 0 0 2
25-Mar-92	X	O	X	O	O	X	Y N Y Y N N N N	1 0 1 1 0 0 0 2
26-Mar-92	X	O	X	O	O	X	Y N Y Y N N N N	1 0 1 1 0 0 0 2
27-Mar-92	X	O	X	O	O	X	Y N Y Y N N N N	1 0 1 1 0 0 0 2
28-Mar-92	X	O	X	O	O	X	Y N Y Y N N N N	1 0 1 1 0 0 0 2
29-Mar-92	X	O	X	O	O	X	Y N Y Y N N N N	1 0 1 1 0 0 0 2
30-Mar-92	X	O	X	O	O	X	Y N Y Y N N N N	1 0 1 1 0 0 0 2
31-Mar-92	X	O	X	O	O	X	Y N Y Y N N N N	1 0 1 1 0 0 0 2

	Shetland	Shetland	Shetland	Hanscom	Hanscom	Thule	Data Processed	Quality Of
	GPS	GPS	Transit	GPS'S	Transit	GPS	From Sites	Processed Data
	STI 5010	TI-4100	UCW PL	STI NIMS	Magnavox	STI 5010	1 2 3 4 5 6 7 8	1 = OK/2 = ?/3 = BAD
1-Apr-92	X	O	X	O	O	X	Y N Y Y N N N N	1 0 1 1 0 0 0 1
2-Apr-92	X	O	X	O	O	X	Y N Y Y N N N N	1 0 1 1 0 0 0 1
3-Apr-92	X	O	X	O	O	X	Y N Y Y N N N N	1 0 1 1 0 0 0 1
4-Apr-92	X	O	X	O	O	X	Y N Y Y N N N N	1 0 1 1 0 0 0 1
5-Apr-92	X	O	X	O	O	X	Y N Y Y N N N N	1 0 1 1 0 0 0 1
6-Apr-92	X	O	X	O	O	X	Y N Y Y N N N N	1 0 1 1 0 0 0 1
7-Apr-92	X	O	X	O	O	X	Y N Y Y N N N N	1 0 1 1 0 0 0 1
8-Apr-92	X	O	X	O	O	X	Y N Y Y N N N N	1 0 1 1 0 0 0 1
9-Apr-92	X	O	X	O	O	X	Y N Y Y N N N N	1 0 1 1 0 0 0 1
10-Apr-92	X	O	X	O	O	X	Y N Y Y N N N N	1 0 1 1 0 0 0 1
11-Apr-92	X	O	X	O	O	X	Y N Y Y N N N N	1 0 1 1 0 0 0 1
12-Apr-92	X	O	X	O	O	X	Y N Y Y N N N N	1 0 1 1 0 0 0 1
13-Apr-92	X	O	X	O	O	X	Y N Y Y N N N N	1 0 1 1 0 0 0 1
14-Apr-92	X	O	X	O	O	X	Y N Y Y N N N N	1 0 1 1 0 0 0 1
15-Apr-92	X	O	X	O	O	X	Y N Y Y N N N N	1 0 1 1 0 0 0 1
16-Apr-92	X	O	X	O	O	X	Y N Y Y N N N N	1 0 1 1 0 0 0 1
17-Apr-92	X	O	X	O	O	X	Y N Y Y N N N N	1 0 1 1 0 0 0 1
18-Apr-92	X	O	X	O	O	X	Y N Y Y N N N N	1 0 1 1 0 0 0 1
19-Apr-92	X	O	X	O	O	X	Y N Y Y N N N N	1 0 1 1 0 0 0 1
20-Apr-92	X	O	X	O	O	X	Y N Y Y N N N N	1 0 1 1 0 0 0 1
21-Apr-92	X	O	X	O	O	X	Y N Y Y N N N N	1 0 1 1 0 0 0 1
22-Apr-92	X	O	X	O	O	X	Y N Y Y N N N N	1 0 1 1 0 0 0 1
23-Apr-92	X	O	X	O X	O	X	Y N Y Y N Y N N	1 0 1 1 0 2 0 2
24-Apr-92	X	O	X	O X	O	X	Y N Y Y N Y N N	1 0 1 1 0 2 0 2
25-Apr-92	X	O	X	O X	O	X	Y N Y Y N Y N N	1 0 1 1 0 2 0 2
26-Apr-92	X	O	X	O X	O	X	Y N Y Y N Y N N	1 0 1 1 0 2 0 2
27-Apr-92	X	O	X	O X	O	X	Y N Y Y N Y N N	1 0 1 1 0 2 0 2
28-Apr-92	X	O	X	O X	O	X	Y N Y Y N Y N N	1 0 1 1 0 2 0 2
29-Apr-92	X	O	X	O X	O	X	Y N Y Y N Y N N	1 0 1 1 0 2 0 2
30-Apr-92	X	O	X	O X	O	X	Y N Y Y N Y N N	1 0 1 1 0 2 0 2

	Shetland GPS STI 5010	Shemya GPS TI-4100	Shetland Transit UCW PL	Hanscom GPS'S STI NIMS	Hanscom Transit Magnavox	Thule GPS STI 5010	Data Processed From Sites 1 2 3 4 5 6 7 8	Quality Of Processed Data 1 = OK/2 = ?/3 = BAD
1-May-92	X	X	X	O X	O	X	Y Y Y Y N Y N N	1 1 1 1 0 2 0 2
2-May-92	X	X	X	O X	O	X	Y Y Y Y N Y N N	1 1 1 1 0 2 0 2
3-May-92	X	X	X	O X	O	X	Y Y Y Y N Y N N	1 1 1 1 0 2 0 2
4-May-92	X	X	X	O X	O	X	Y Y Y Y N Y N N	1 1 1 1 0 2 0 2
5-May-92	X	X	X	O X	O	X	Y Y Y Y N Y N N	1 1 1 1 0 2 0 2
6-May-92	X	X	X	O X	O	X	Y Y Y Y N Y N N	1 1 1 1 0 2 0 2
7-May-92	X	X	X	O X	O	X	Y Y Y Y N Y N N	1 1 1 1 0 2 0 2
8-May-92	X	X	X	O X	O	X	Y Y Y Y N Y N N	1 1 1 1 0 2 0 2
9-May-92	X	X	X	O X	O	X	Y Y Y Y N Y N N	1 1 1 1 0 2 0 2
10-May-92	X	X	X	O X	O	X	Y Y Y Y N Y N N	1 1 1 1 0 2 0 2
11-May-92	X	X	X	O X	O	X	Y Y Y Y N Y N N	1 1 1 1 0 2 0 2
12-May-92	X	X	X	O X	O	X	Y Y Y Y N Y N N	1 1 1 1 0 2 0 2
13-May-92	X	X	X	O X	O	X	Y Y Y Y N Y N N	1 1 1 1 0 2 0 2
14-May-92	X	X	X	O X	O	X	Y Y Y Y N Y N N	1 1 1 1 0 2 0 2
15-May-92	X	X	X	O X	O	X	Y Y Y Y N Y N N	1 1 1 1 0 2 0 2
16-May-92	X	X	X	O X	O	X	Y Y Y Y N Y N N	1 1 1 1 0 2 0 2
17-May-92	X	X	X	O X	O	X	Y Y Y Y N Y N N	1 1 1 1 0 2 0 2
18-May-92	X	X	X	O X	O	X	Y Y Y Y N Y N N	1 1 1 1 0 2 0 2
19-May-92	X	X	X	O X	O	X	Y Y Y Y N Y N N	1 1 1 1 0 2 0 2
20-May-92	X	X	X	O X	O	X	Y Y Y Y N Y N N	1 1 1 1 0 2 0 2
21-May-92	X	X	X	O X	O	X	Y Y Y Y N Y N N	1 1 1 1 0 2 0 2
22-May-92	X	X	X	O X	O	X	Y Y Y Y N Y N N	1 1 1 1 0 2 0 2
23-May-92	X	X	X	O X	O	X	Y Y Y Y N Y N N	1 1 1 1 0 2 0 2
24-May-92	X	X	X	O X	O	X	Y Y Y Y N Y N N	1 1 1 1 0 2 0 2
25-May-92	X	X	X	O X	O	X	Y Y Y Y N Y N N	1 1 1 1 0 2 0 2
26-May-92	X	X	X	O X	O	X	Y Y Y Y N Y N N	1 1 1 1 0 2 0 2
27-May-92	X	X	X	O X	O	X	Y Y Y Y N Y N N	1 1 1 1 0 2 0 2
28-May-92	X	X	X	O X	O	X	Y Y Y Y N Y N N	1 1 1 1 0 2 0 2
29-May-92	X	X	X	O X	O	X	Y Y Y Y N Y N N	1 1 1 1 0 2 0 2
30-May-92	X	X	X	O X	O	X	Y Y Y Y N Y N N	1 1 1 1 0 2 0 2
31-Ma 92	X	X	X	O X	O	X	Y Y Y Y N Y N N	1 1 1 1 0 2 0 2

	Shetland	Shemya	Shetland		Hanscom		Hanscom	Thule	Data Processed	Quality Of
	GPS	GPS	Transit		GPS'S		Transit	GPS	From Sites	Processed Data
	STI 5010	TI-4100	UCW	PL	STI	NIMS	Magnavox	STI 5010	1|2|3|4|5|6|7|8|	1 = OK/2 = ?/3 = BAD
1-Jun-92	X	X	X	X	0	X	0	X	Y|Y|Y|Y|N|Y|N|N|	1|1|1|1|0|2|0|2|
2-Jun-92	X	X	X	X	0	X	0	X	Y|Y|Y|Y|N|Y|N|N|	1|1|1|1|0|2|0|2|
3-Jun-92	X	X	X	X	0	X	0	X	Y|Y|Y|Y|N|Y|N|N|	1|1|1|1|0|2|0|2|
4-Jun-92	X	X	X	X	0	X	0	X	Y|Y|Y|Y|N|Y|N|N|	1|1|1|1|0|2|0|2|
5-Jun-92	X	X	X	X	0	X	0	X	Y|Y|Y|Y|N|Y|N|N|	1|1|1|1|0|2|0|2|
6-Jun-92	X	X	X	X	0	X	0	X	Y|Y|Y|Y|N|Y|N|N|	1|1|1|1|0|2|0|2|
7-Jun-92	X	X	X	0	0	X	0	X	Y|Y|Y|N|N|Y|N|N|	1|1|1|0|0|2|0|2|
8-Jun-92	X	X	X	0	0	X	0	X	Y|Y|Y|N|N|Y|N|N|	1|1|1|0|0|2|0|2|
9-Jun-92	X	X	X	0	0	X	0	X	Y|Y|Y|N|N|Y|N|N|	1|1|1|0|0|2|0|2|
10-Jun-92	X	X	X	0	0	X	0	X	Y|Y|Y|N|N|Y|N|N|	1|1|1|0|0|2|0|2|
11-Jun-92	X	X	X	0	0	X	0	X	Y|Y|Y|N|N|Y|N|N|	1|1|1|0|0|2|0|2|
12-Jun-92	X	X	X	0	0	X	0	X	Y|Y|Y|N|N|Y|N|N|	1|1|1|0|0|2|0|2|
13-Jun-92	X	X	X	0	0	X	0	X	Y|Y|Y|N|N|Y|N|N|	1|1|1|0|0|2|0|2|
14-Jun-92	X	X	X	0	0	X	0	X	Y|Y|Y|N|N|Y|N|N|	1|1|1|0|0|2|0|2|
15-Jun-92	X	X	X	0	0	X	0	X	Y|Y|Y|N|N|Y|N|N|	1|1|1|0|0|2|0|2|
16-Jun-92	X	X	X	0	0	X	0	X	Y|Y|Y|N|N|Y|N|N|	1|1|1|0|0|2|0|2|
17-Jun-92	X	X	X	0	0	X	0	X	Y|Y|Y|N|N|Y|N|N|	1|1|1|0|0|2|0|2|
18-Jun-92	X	X	X	0	0	X	0	X	Y|Y|Y|N|N|Y|N|N|	1|1|1|0|0|2|0|2|
19-Jun-92	0	X	X	0	0	X	0	X	N|Y|Y|N|N|Y|N|N|	0|1|1|0|0|2|0|2|
20-Jun-92	0	X	X	0	0	X	0	X	N|Y|Y|N|N|Y|N|N|	0|1|1|0|0|2|0|2|
21-Jun-92	0	X	X	0	0	X	0	X	N|Y|Y|N|N|Y|N|N|	0|1|1|0|0|2|0|2|
22-Jun-92	0	X	X	0	0	X	0	X	N|Y|Y|N|N|Y|N|N|	0|1|1|0|0|2|0|2|
23-Jun-92	0	X	X	0	0	X	0	X	N|Y|Y|N|N|Y|N|N|	0|1|1|0|0|2|0|2|
24-Jun-92	0	X	X	0	0	X	0	X	N|Y|Y|N|N|Y|N|N|	0|1|1|0|0|2|0|2|
25-Jun-92	0	X	X	0	0	X	0	X	N|Y|Y|N|N|Y|N|N|	0|1|1|0|0|2|0|2|
26-Jun-92	0	X	X	0	0	X	0	X	N|Y|Y|N|N|Y|N|N|	0|1|1|0|0|2|0|2|
27-Jun-92	0	X	X	0	0	X	0	X	N|Y|Y|N|N|Y|N|N|	0|1|1|0|0|2|0|2|
28-Jun-92	0	X	X	0	0	X	0	X	N|Y|Y|N|N|Y|N|N|	0|1|1|0|0|2|0|2|
29-Jun-92	0	X	X	0	0	X	0	X	N|Y|Y|N|N|Y|N|N|	0|1|1|0|0|2|0|2|
30-Jun-92	0	X	X	0	0	X	0	X	N|Y|Y|N|N|Y|N|N|	0|1|1|0|0|2|0|2|

	Shetland GPS STI 5010	Shemya GPS TI-4100	Shetland Transit UCW	PL	Hanscom GPS'S STI	NIMS	Hanscom Transit Magnavox	Thule GPS STI 5010	Data Processed From Sites 1 2 3 4 5 6 7 8	Quality Of Processed Data 1 = OK/2 = ?/3 = BAD
1-Jul-92	O	X	X	O	O	X	O	X	N Y Y N N Y N N	0 1 1 0 0 2 0 2
2-Jul-92	O	X	X	O	O	X	O	X	N Y Y N N Y N N	0 1 1 0 0 2 0 2
3-Jul-92	O	X	X	O	O	X	O	X	N Y Y N N Y N N	0 1 1 0 0 2 0 2
4-Jul-92	O	X	X	O	O	X	O	X	N Y Y N N Y N N	0 1 1 0 0 2 0 2
5-Jul-92	O	X	X	O	O	X	O	X	N Y Y N N Y N N	0 1 1 0 0 2 0 2
6-Jul-92	O	X	X	O	O	X	O	X	N Y Y N N Y N N	0 1 1 0 0 2 0 2
7-Jul-92	O	X	X	O	O	X	O	X	N Y Y N N Y N N	0 1 1 0 0 2 0 2
8-Jul-92	O	X	X	O	O	X	O	X	N Y Y N N Y N N	0 1 1 0 0 2 0 2
9-Jul-92	O	X	X	O	O	X	O	X	N Y Y N N Y N N	0 1 1 0 0 2 0 2
10-Jul-92	O	X	X	O	O	X	O	X	N Y Y N N Y N N	0 1 1 0 0 2 0 2
11-Jul-92	O	X	X	O	O	X	O	X	N Y Y N N Y N N	0 1 1 0 0 2 0 2
12-Jul-92	O	X	X	O	O	X	O	X	N Y Y N N Y N N	0 1 1 0 0 2 0 2
13-Jul-92	O	X	X	O	O	X	O	X	N Y Y N N Y N N	0 1 1 0 0 2 0 2
14-Jul-92	O	X	X	O	O	X	O	X	N Y Y N N Y N N	0 1 1 0 0 2 0 2
15-Jul-92	O	X	X	O	O	X	O	X	N Y Y N N Y N N	0 1 1 0 0 2 0 2
16-Jul-92	O	X	X	O	O	X	O	X	N Y Y N N Y N N	0 1 1 0 0 2 0 2
17-Jul-92	O	X	X	O	O	X	O	X	N Y Y N N Y N N	0 1 1 0 0 2 0 2
18-Jul-92	O	X	X	O	O	X	O	X	N Y Y N N Y N N	0 1 1 0 0 2 0 2
19-Jul-92	O	X	X	O	O	X	O	X	N Y Y N N Y N N	0 1 1 0 0 2 0 2
20-Jul-92	O	X	X	O	O	X	O	X	N Y Y N N Y N N	0 1 1 0 0 2 0 2
21-Jul-92	O	X	X	O	O	X	O	X	N Y Y N N Y N N	0 1 1 0 0 2 0 2
22-Jul-92	O	X	X	O	O	X	O	X	N Y Y N N Y N N	0 1 1 0 0 2 0 2
23-Jul-92	O	X	X	O	O	X	O	X	N Y Y N N Y N N	0 1 1 0 0 2 0 2
24-Jul-92	O	X	X	O	O	X	O	X	N Y Y N N Y N N	0 1 1 0 0 2 0 2
25-Jul-92	O	X	X	O	O	X	O	X	N Y Y N N Y N N	0 1 1 0 0 2 0 2
26-Jul-92	O	X	X	O	O	X	O	X	N Y Y N N Y N N	0 1 1 0 0 2 0 2
27-Jul-92	O	X	X	O	O	X	O	X	N Y Y N N Y N N	0 1 1 0 0 2 0 2
28-Jul-92	O	X	X	O	O	X	O	X	N Y Y N N Y N N	0 1 1 0 0 2 0 2
29-Jul-92	O	X	X	O	O	X	O	X	N Y Y N N Y N N	0 1 1 0 0 2 0 2
30-Jul-92	O	X	X	O	O	X	O	X	N Y Y N N Y N N	0 1 1 0 0 2 0 2
31-Jul-92	O	X	X	O	O	X	O	X	N Y Y N N Y N N	0 1 1 0 0 2 0 2

	Shetland	Shemya	Shetland		Hanscom		Hanscom	Thule	Data Processed	Quality Of
	GPS	GPS	Transit		GPS'S		Transit	GPS	From Sites	Processed Data
	STI 5010	TI-4100	UCW	PL	STI	NIMS	Magnavox	STI 5010	1 2 3 4 5 6 7 8	1 = OK/2 = ?/3 = BAD
1-Aug-92	O	X	X	O	O	X	O	X	N Y Y N N Y N N	0 1 1 0 0 2 0 2
2-Aug-92	O	X	X	O	O	X	O	X	N Y Y N N Y N N	0 1 1 0 0 2 0 2
3-Aug-92	O	X	X	O	O	X	O	X	N Y Y N N Y N N	0 1 1 0 0 2 0 2
4-Aug-92	O	X	X	O	O	X	O	X	N Y Y N N Y N N	0 1 1 0 0 2 0 2
5-Aug-92	O	X	X	O	O	X	O	X	N Y Y N N Y N N	0 1 1 0 0 2 0 2
6-Aug-92	O	X	X	O	O	X	O	X	N Y Y N N Y N N	0 1 1 0 0 2 0 2
7-Aug-92	O	X	X	O	O	X	O	X	N Y Y N N Y N N	0 1 1 0 0 2 0 2
8-Aug-92	O	X	X	O	O	X	O	X	N Y Y N N Y N N	0 1 1 0 0 2 0 2
9-Aug-92	O	X	X	O	O	X	O	X	N Y Y N N Y N N	0 1 1 0 0 2 0 2
10-Aug-92	O	X	X	O	O	X	O	X	N Y Y N N Y N N	0 1 1 0 0 2 0 2
11-Aug-92	O	X	X	O	O	X	O	X	N Y Y N N Y N N	0 1 1 0 0 2 0 2
12-Aug-92	O	X	X	O	O	X	O	X	N Y Y N N Y N N	0 1 1 0 0 2 0 2
13-Aug-92	O	X	X	O	O	X	O	X	N Y Y N N Y N N	0 1 1 0 0 2 0 2
14-Aug-92	O	X	X	O	O	X	O	X	N Y Y N N Y N N	0 1 1 0 0 2 0 2
15-Aug-92	O	X	X	O	O	X	O	X	N Y Y N N Y N N	0 1 1 0 0 2 0 2
16-Aug-92	O	X	X	O	O	X	O	X	N Y Y N N Y N N	0 1 1 0 0 2 0 2
17-Aug-92	O	X	X	O	O	X	O	X	N Y Y N N Y N N	0 1 1 0 0 2 0 2
18-Aug-92	O	X	X	O	O	X	O	X	N Y Y N N Y N N	0 1 1 0 0 2 0 2
19-Aug-92	O	X	X	O	O	X	O	X	N Y Y N N Y N N	0 1 1 0 0 2 0 2
20-Aug-92	O	X	X	O	O	X	O	X	N Y Y N N Y N N	0 1 1 0 0 2 0 2
21-Aug-92	O	X	X	O	O	X	O	X	N Y Y N N Y N N	0 1 1 0 0 2 0 2
22-Aug-92	O	X	X	O	O	X	O	X	N Y Y N N Y N N	0 1 1 0 0 2 0 2
23-Aug-92	O	X	X	O	O	X	O	X	N Y Y N N Y N N	0 1 1 0 0 2 0 2
24-Aug-92	O	X	X	O	O	X	O	X	N Y Y N N Y N N	0 1 1 0 0 2 0 2
25-Aug-92	O	X	X	O	O	X	O	X	N Y Y N N Y N N	0 1 1 0 0 2 0 2
26-Aug-92	O	X	X	O	O	X	O	X	N Y Y N N Y N N	0 1 1 0 0 2 0 2
27-Aug-92	O	X	X	O	O	X	O	X	N Y Y N N Y N N	0 1 1 0 0 2 0 2
28-Aug-92	O	X	X	O	O	X	O	X	N Y Y N N Y N N	0 1 1 0 0 2 0 2
29-Aug-92	O	X	X	O	O	X	O	X	N Y Y N N Y N N	0 1 1 0 0 2 0 2
30-Aug-92	O	X	X	O	O	X	O	X	N Y Y N N Y N N	0 1 1 0 0 2 0 2
31-Aug-92	O	X	X	O	O	X	O	X	N Y Y N N Y N N	0 1 1 0 0 2 0 2

	Shetland	Shemya	Shetland		Hanscom		Hanscom	Thule	Data Processed	Quality Of
	GPS	GPS	Transit		GPS'S		Transit	GPS	From Sites	Processed Data
	STI 5010	TI-4100	UCW	PL	STI	NIMS	Magnavox	STI 5010	1 2 3 4 5 6 7 8	1 = OK/2 = ?/3 = BAD
1-Sep-92	0	X	X	0	0	X	X	X	N Y Y N N Y Y N	0 1 2 0 0 2 1 2
2-Sep-92	0	X	X	0	0	X	X	X	N Y Y N N Y Y N	0 1 2 0 0 2 1 2
3-Sep-92	0	X	X	0	0	X	X	X	N Y Y N N Y Y N	0 1 2 0 0 2 1 2
4-Sep-92	0	X	X	0	0	X	X	X	N Y Y N N Y Y N	0 1 2 0 0 2 1 2
5-Sep-92	0	X	X	0	0	X	X	X	N Y Y N N Y Y N	0 1 2 0 0 2 1 2
6-Sep-92	0	X	X	0	0	X	X	X	N Y Y N N Y Y N	0 1 2 0 0 2 1 2
7-Sep-92	0	X	X	0	0	X	X	X	N Y Y N N Y Y N	0 1 2 0 0 2 1 2
8-Sep-92	0	X	X	0	0	X	X	X	N Y Y N N Y Y N	0 1 2 0 0 2 1 2
9-Sep-92	0	X	X	0	0	X	X	X	N Y Y N N Y Y N	0 1 2 0 0 2 1 2
10-Sep-92	0	X	X	0	0	X	X	X	N Y Y N N Y Y N	0 1 2 0 0 2 1 2
11-Sep-92	0	X	X	0	0	X	X	X	N Y Y N N Y Y N	0 1 2 0 0 2 1 2
12-Sep-92	0	X	X	0	0	X	X	X	N Y Y N N Y Y N	0 1 2 0 0 2 1 2
13-Sep-92	0	X	X	0	0	X	X	X	N Y Y N N Y Y N	0 1 2 0 0 2 1 2
14-Sep-92	0	X	X	0	0	X	X	X	N Y Y N N Y Y N	0 1 2 0 0 2 1 2
15-Sep-92	0	X	X	0	0	X	X	X	N Y Y N N Y Y N	0 1 2 0 0 2 1 2
16-Sep-92	0	X	X	0	0	X	X	X	N Y Y N N Y Y N	0 1 2 0 0 2 1 2
17-Sep-92	0	X	X	0	0	X	X	X	N Y Y N N Y Y N	0 1 2 0 0 2 1 2
18-Sep-92	0	X	X	0	0	X	X	X	N Y Y N N Y Y N	0 1 2 0 0 2 1 2
19-Sep-92	0	X	X	0	0	X	X	X	N Y Y N N Y Y N	0 1 2 0 0 2 1 2
20-Sep-92	0	X	X	0	0	X	X	X	N Y Y N N Y Y N	0 1 2 0 0 2 1 2
21-Sep-92	0	X	X	0	0	X	X	X	N Y Y N N Y Y N	0 1 2 0 0 2 1 2
22-Sep-92	0	X	X	0	0	X	X	X	N Y Y N N Y Y N	0 1 2 0 0 2 1 2
23-Sep-92	0	X	X	0	0	X	X	X	N Y Y N N Y Y N	0 1 2 0 0 2 1 2
24-Sep-92	0	X	X	0	0	X	X	X	N Y Y N N Y Y N	0 1 2 0 0 2 1 2
25-Sep-92	0	X	X	0	0	X	X	X	N Y Y N N Y Y N	0 1 2 0 0 2 1 2
26-Sep-92	0	X	X	0	0	X	X	X	N Y Y N N Y Y N	0 1 2 0 0 2 1 2
27-Sep-92	0	X	X	0	0	X	X	X	N Y Y N N Y Y N	0 1 2 0 0 2 1 2
28-Sep-92	0	X	X	0	0	X	X	X	N Y Y N N Y Y N	0 1 2 0 0 2 1 2
29-Sep-92	0	X	X	0	0	X	X	X	N Y Y N N Y Y N	0 1 2 0 0 2 1 2
30-Sep-92	0	X	X	0	0	X	X	X	N Y Y N N Y Y N	0 1 2 0 0 2 1 2

	Shetland GPS STI 5010	Shemya GPS TI-4100	Shetland Transit UCW PL	Hanscom GPS'S STI NIMS	Hanscom Transit Magnavox	Thule GPS STI 5010	Data Processed From Sites 1 2 3 4 5 6 7 8	Quality Of Processed Data 1 = OK/2 = ?/3 = BAD
1-Oct-92	O	X	X O	O X	X	X	N Y Y N N Y Y N	0 1 2 0 0 2 1 2
2-Oct-92	O	X	X O	O X	X	X	N Y Y N N Y Y N	0 1 2 0 0 2 1 2
3-Oct-92	O	X	X O	O X	X	X	N Y Y N N Y Y N	0 1 2 0 0 2 1 2
4-Oct-92	O	X	X O	O X	X	X	N Y Y N N Y Y N	0 1 2 0 0 2 1 2
5-Oct-92	O	X	X O	O X	X	X	N Y Y N N Y Y N	0 1 2 0 0 2 1 2
6-Oct-92	O	X	X O	O X	X	X	N Y Y N N Y Y N	0 1 2 0 0 2 1 2
7-Oct-92	O	X	X O	O X	X	X	N Y Y N N Y Y N	0 1 2 0 0 2 1 2
8-Oct-92	O	X	X O	O X	X	X	N Y Y N N Y Y N	0 1 2 0 0 2 1 2
9-Oct-92	O	X	X O	O X	X	X	N Y Y N N Y Y N	0 1 2 0 0 2 1 2
10-Oct-92	O	X	X O	O X	X	X	N Y Y N N Y Y N	0 1 2 0 0 2 1 2
11-Oct-92	O	X	X O	O X	X	X	N Y Y N N Y Y N	0 1 2 0 0 2 1 2
12-Oct-92	O	X	X O	O X	X	X	N Y Y N N Y Y N	0 1 2 0 0 2 1 2
13-Oct-92	O	X	X O	O X	X	X	N Y Y N N Y Y N	0 1 2 0 0 2 1 2
14-Oct-92	O	X	X O	O X	X	X	N Y Y N N Y Y N	0 1 2 0 0 2 1 2
15-Oct-92	O	X	X O	O X	X	X	N Y Y N N Y Y N	0 1 2 0 0 2 1 2
16-Oct-92	O	X	X O	O X	X	X	N Y Y N N Y Y N	0 1 2 0 0 2 1 2
17-Oct-92	O	X	X O	O X	X	X	N Y Y N N Y Y N	0 1 2 0 0 2 1 2
18-Oct-92	O	X	X O	O X	X	X	N Y Y N N Y Y N	0 1 2 0 0 2 1 2
19-Oct-92	O	X	X O	O X	X	X	N Y Y N N Y Y N	0 1 2 0 0 2 1 2
20-Oct-92	O	X	X O	O X	X	X	N Y Y N N Y Y N	0 1 2 0 0 2 1 2
21-Oct-92	O	X	X O	O X	X	X	N Y Y N N Y Y N	0 1 2 0 0 2 1 2
22-Oct-92	O	X	X O	O X	X	X	N Y Y N N Y Y N	0 1 2 0 0 2 1 2
23-Oct-92	O	X	X O	O X	X	X	N Y Y N N Y Y N	0 1 2 0 0 2 1 2
24-Oct-92	O	X	X O	O X	X	X	N Y Y N N Y Y N	0 1 2 0 0 2 1 2
25-Oct-92	O	X	X O	O X	X	X	N Y Y N N Y Y N	0 1 2 0 0 2 1 2
26-Oct-92	O	X	X O	O X	X	X	N Y Y N N Y Y N	0 1 2 0 0 2 1 2
27-Oct-92	O	X	X O	O X	X	X	N Y Y N N Y Y N	0 1 2 0 0 2 1 2
28-Oct-92	O	X	X O	O X	X	X	N Y Y N N Y Y N	0 1 2 0 0 2 1 2
29-Oct-92	O	X	X O	O X	X	X	N Y Y N N Y Y N	0 1 2 0 0 2 1 2
30-Oct-92	O	X	X O	O X	X	X	N Y Y N N Y Y N	0 1 2 0 0 2 1 2
31-Oct-92	O	X	X O	O X	X	X	N Y Y N N Y Y N	0 1 2 0 0 2 1 2

	Shetland	Shemya	Shetland		Hanscom		Hanscom	Thule	Data Processed	Quality Of
	GPS	GPS	Transit		GPS'S		Transit	GPS	From Sites	Processed Data
	STI 5010	TI-4100	UCW	PL	STI	NIMS	Magnavox	STI 5010	1 2 3 4 5 6 7 8	1 = OK/2 = ?/3 = BAD
1-Nov-92	O	X	X	O	O	X	X	X	N Y Y N N Y Y N	0 1 2 0 0 2 1 2
2-Nov-92	O	X	X	O	O	X	X	X	N Y Y N N Y Y N	0 1 2 0 0 2 1 2
3-Nov-92	O	X	X	O	O	X	X	X	N Y Y N N Y Y N	0 1 2 0 0 2 1 2
4-Nov-92	O	X	X	O	O	X	X	X	N Y Y N N Y Y N	0 1 2 0 0 2 1 2
5-Nov-92	O	X	X	O	O	X	X	X	N Y Y N N Y Y N	0 1 2 0 0 2 1 2
6-Nov-92	O	X	X	O	O	X	X	X	N Y Y N N Y Y N	0 1 2 0 0 2 1 2
7-Nov-92	O	X	X	O	O	X	X	X	N Y Y N N Y Y N	0 1 2 0 0 2 1 2
8-Nov-92	O	X	X	O	O	X	X	X	N Y Y N N Y Y N	0 1 2 0 0 2 1 2
9-Nov-92	O	X	X	O	O	X	X	X	N Y Y N N Y Y N	0 1 2 0 0 2 1 2
10-Nov-92	O	X	X	O	O	X	X	X	N Y Y N N Y Y N	0 1 2 0 0 2 1 2
11-Nov-92	O	X	X	O	O	X	X	X	N Y Y N N Y Y N	0 1 2 0 0 2 1 2
12-Nov-92	O	X	X	O	O	X	X	X	N Y Y N N Y Y N	0 1 2 0 0 2 1 2
13-Nov-92	O	X	X	O	O	X	X	X	N Y Y N N Y Y N	0 1 2 0 0 2 1 2
14-Nov-92	O	X	X	O	O	X	X	X	N Y Y N N Y Y N	0 1 2 0 0 2 1 2
15-Nov-92	O	X	X	O	O	X	X	X	N Y Y N N Y Y N	0 1 2 0 0 2 1 2
16-Nov-92	O	X	X	O	O	X	X	X	N Y Y N N Y Y N	0 1 2 0 0 2 1 2
17-Nov-92	O	X	X	O	O	X	X	X	N Y Y N N Y Y N	0 1 2 0 0 2 1 2
18-Nov-92	O	X	X	O	O	X	X	X	N Y Y N N Y Y N	0 1 2 0 0 2 1 2
19-Nov-92	O	X	X	O	O	X	X	X	N Y Y N N Y Y N	0 1 2 0 0 2 1 2
20-Nov-92	O	X	X	O	O	X	X	X	N Y Y N N Y Y N	0 1 2 0 0 2 1 2
21-Nov-92	O	X	X	O	O	X	X	X	N Y Y N N Y Y N	0 1 2 0 0 2 1 2
22-Nov-92	O	X	X	O	O	X	X	X	N Y Y N N Y Y N	0 1 2 0 0 2 1 2
23-Nov-9	O	X	X	O	O	X	X	X	N Y Y N N Y Y N	0 1 2 0 0 2 1 2
24-Nov-9	O	X	X	O	O	X	X	X	N Y Y N N Y Y N	0 1 2 0 0 2 1 2
25-Nov-92	O	X	X	O	O	X	X	X	N Y Y N N Y Y N	0 1 2 0 0 2 1 2
26-Nov-92	O	X	X	O	O	X	X	X	N Y Y N N Y Y N	0 1 2 0 0 2 1 2
27-Nov-92	O	X	X	O	O	X	X	X	N Y Y N N Y Y N	0 1 2 0 0 2 1 2
28-Nov-92	O	X	X	O	O	X	X	O	N Y Y N N Y Y N	0 1 2 0 0 2 1 0
29-Nov-92	O	X	X	O	O	X	X	O	N Y Y N N Y Y N	0 1 2 0 0 2 1 0
30-Nov-92	O	X	X	O	O	X	X	O	N Y Y N N Y Y N	0 1 2 0 0 2 1 0

	Shetland	Shemya	Shetland		Hanscom		Hanscom	Thule	Data Processed	Quality Of
	GPS	GPS	Transit		GPS'S		Transit	GPS	From Sites	Processed Data
	STI 5010	TI-4100	UCW	PL	STI	NIMS	Magnavox	STI 5010	1 2 3 4 5 6 7 8	1 = OK/2 = ?/3 = BAD
1-Dec-92	0	X	X	0	0	X	0	0	N Y Y N N Y N N	0 1 2 0 0 2 0 0
2-Dec-92	0	X	X	0	0	X	0	0	N Y Y N N Y N N	0 1 2 0 0 2 0 0
3-Dec-92	0	X	X	0	0	X	0	0	N Y Y N N Y N N	0 1 2 0 0 2 0 0
4-Dec-92	0	X	X	0	0	X	0	0	N Y Y N N Y N N	0 1 2 0 0 2 0 0
5-Dec-92	0	X	X	0	0	X	0	0	N Y Y N N Y N N	0 1 2 0 0 2 0 0
6-Dec-92	0	X	X	0	0	X	0	0	N Y Y N N Y N N	0 1 2 0 0 2 0 0
7-Dec-92	0	X	X	0	0	X	0	0	N Y Y N N Y N N	0 1 2 0 0 2 0 0
8-Dec-92	0	X	X	0	0	X	0	0	N Y Y N N Y N N	0 1 2 0 0 2 0 0
9-Dec-92	0	X	X	0	0	X	0	0	N Y Y N N Y N N	0 1 2 0 0 2 0 0
10-Dec-92	0	X	X	0	0	X	0	0	N Y Y N N Y N N	0 1 2 0 0 2 0 0
11-Dec-92	0	X	X	0	0	X	0	0	N Y Y N N Y N N	0 1 2 0 0 2 0 0
12-Dec-92	0	X	X	0	0	X	0	0	N Y Y N N Y N N	0 1 2 0 0 2 0 0
13-Dec-92	0	X	X	0	0	X	0	0	N Y Y N N Y N N	0 1 2 0 0 2 0 0
14-Dec-92	0	X	X	0	0	X	0	0	N Y Y N N Y N N	0 1 2 0 0 2 0 0
15-Dec-92	0	X	X	0	0	X	0	0	N Y Y N N Y N N	0 1 2 0 0 2 0 0
16-Dec-92	0	X	X	0	0	X	0	0	N Y Y N N Y N N	0 1 2 0 0 2 0 0
17-Dec-92	0	X	X	0	0	X	0	0	N Y Y N N Y N N	0 1 2 0 0 2 0 0
18-Dec-92	0	X	X	0	0	X	0	0	N Y Y N N Y N N	0 1 2 0 0 2 0 0
19-Dec-92	0	X	X	0	0	X	0	0	N Y Y N N Y N N	0 1 2 0 0 2 0 0
20-Dec-92	0	X	X	0	0	X	0	0	N Y Y N N Y N N	0 1 2 0 0 2 0 0
21-Dec-92	0	X	X	0	0	X	0	0	N Y Y N N Y N N	0 1 2 0 0 2 0 0
22-Dec-92	0	X	X	0	0	X	0	0	N Y Y N N Y N N	0 1 2 0 0 2 0 0
23-Dec-92	0	X	X	0	0	X	0	0	N Y Y N N Y N N	0 1 2 0 0 2 0 0
24-Dec-92	0	X	X	0	0	X	0	0	N Y Y N N Y N N	0 1 2 0 0 2 0 0
25-Dec-92	0	X	X	0	0	X	0	0	N Y Y N N Y N N	0 1 2 0 0 2 0 0
26-Dec-92	0	X	X	0	0	X	0	0	N Y Y N N Y N N	0 1 2 0 0 2 0 0
27-Dec-92	0	X	X	0	0	X	0	0	N Y Y N N Y N N	0 1 2 0 0 2 0 0
28-Dec-92	0	X	X	0	0	X	0	0	N Y Y N N Y N N	0 1 2 0 0 2 0 0
29-Dec-92	0	X	X	0	0	X	0	0	N Y Y N N Y N N	0 1 2 0 0 2 0 0
30-Dec-92	0	X	X	0	0	X	0	0	N Y Y N N Y N N	0 1 2 0 0 2 0 0
31-Dec-92	0	X	X	0	0	X	0	0	N Y Y N N Y N N	0 1 2 0 0 2 0 0